NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(241)
July 1989

National Aeronautics and Space Administration

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ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)	N89-18407 — N89-20085
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NASA SP-7037(241)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 241)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in June 1989 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA
National Aeronautics and Space Administration
Office of Management
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Washington, DC 1989

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 526 reports, journal articles and other documents originally announced in June 1989 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → N89-10029*# North Carolina State Univ., Raleigh. Dept. of ← CORPORATE SOURCE
Mechanical and Aerospace Engineering.

TITLE → **A TRANSONIC INTERACTIVE BOUNDARY-LAYER THEORY FOR LAMINAR AND TURBULENT FLOW OVER SWEPT WINGS Final Report**

AUTHORS → SHAWN H. WOODSON and FRED R. DEJARNETTE
Washington Oct. 1988 82 p

CONTRACT NUMBER → (Contract NCC1-22) — PUBLICATION DATE

REPORT NUMBERS → (NASA-CR-4185; NAS 1.26:4185) Avail: NTIS HC A05/MF A01 ← PRICE CODE

COSATI CODE → CSCL 01A — AVAILABILITY SOURCE

A 3-D laminar and turbulent boundary-layer method is developed for compressible flow over swept wings. The governing equations and curvature terms are derived in detail for a nonorthogonal, curvilinear coordinate system. Reynolds shear-stress terms are modeled by the Cebeci-Smith eddy-viscosity formulation. The governing equations are descretized using the second-order accurate, predictor-corrector finite-difference technique of Matsuno, which has the advantage that the crossflow difference formulas are formed independent of the sign of the crossflow velocity component. The method is coupled with a full potential wing/body inviscid code (FLO-30) and the inviscid-viscous interaction is performed by updating the original wing surface with the viscous displacement surface calculated by the boundary-layer code. The number of these global iterations ranged from five to twelve depending on Mach number, sweep angle, and angle of attack. Several test cases are computed by this method and the results are compared with another inviscid-viscous interaction method (TAWFIVE) and with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → A89-12562*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TITLE → **EFFICIENT VIBRATION MODE ANALYSIS OF AIRCRAFT WITH MULTIPLE EXTERNAL STORE CONFIGURATIONS**

AUTHOR → M. KARPEL (NASA, Langley Research Center, Hampton, VA; Israel Aircraft Industries, Ltd., Lod) Journal of Aircraft (ISSN 0021-8669), ← JOURNAL TITLE
vol. 25, Aug. 1988, p. 747-751. refs

A coupling method for efficient vibration mode analysis of aircraft with multiple external store configurations is presented. A set of low-frequency vibration modes, including rigid-body modes, represent the aircraft. Each external store is represented by its vibration modes with clamped boundary conditions, and by its rigid-body inertial properties. The aircraft modes are obtained from a finite-element model loaded by dummy rigid external stores with fictitious masses. The coupling procedure unloads the dummy stores and loads the actual stores instead. The analytical development is presented, the effects of the fictitious mass magnitudes are discussed, and a numerical example is given for a combat aircraft with external wing stores. Comparison with vibration modes obtained by a direct (full-size) eigensolution shows very accurate coupling results. Once the aircraft and stores data bases are constructed, the computer time for analyzing any external store configuration is two to three orders of magnitude less than that of a direct solution. Author

01

AERONAUTICS (GENERAL)

A89-29175

AIRLINES URGED NOT TO PAINT FUSELAGES AS CONCERNS ABOUT AGING FLEET RISE

JAMES OTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, Feb. 6, 1989, p. 62-64.

The leading U.S. producer of skin aluminum alloy feedstocks for commercial aircraft manufacturers has recommended against any further painting of fuselage skins with airliner livery, in view of such coatings' ability to hinder inspections for cracks developing along rows of rivets and on the lap splices connecting fuselage panels. The hindrance to accurate inspection is exacerbated by the eventual buildup of several layers of paint, as frequently encountered in the older aircraft most urgently requiring such inspection. Especially worrysome is the development of differential weathering and corrosion as older paint coatings chip or scratch. If fuselage painting is desired as an anticorrosion measure, complete stripping of previous paint layers is recommended. O.C.

A89-29442

NATIONAL AEROSPACE PLANE TECHNOLOGY DEVELOPMENT

ROBERT O. PRICE Aerospace Engineering (ISSN 0736-2536), vol. 9, Feb. 1989, p. 15-19.

A development status evaluation is presented for the NASA/DARPA National Aerospace Plane, or 'NASP' program, whose near-term goal is the design, manufacture, and flight-testing of two hydrogen-fueled, scramjet-powered research aircraft for the investigation of sustained hypersonic cruise in the Mach 5-15 range and the ultimate demonstration of a single-stage-to-orbit capability. Attention is given to problems of refractory airframe materials selection, the use of heat pipe-based active cooling, propulsion system/airframe configuration integration, liquid hydrogen tankage, and hypersonic aerothermodynamics. O.C.

A89-29451

NATIONAL TECHNICAL SPECIALISTS' MEETING ON ADVANCED ROTORCRAFT STRUCTURES, WILLIAMSBURG, VA, OCT. 25-27, 1988, PROCEEDINGS

Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1988, 363 p. For individual items see A89-29452 to A89-29475.

The present conference discusses topics encompassing the performance requirements, characteristic loadings, integrity and durability criteria, analysis methods, manufacturing techniques, and configurations of advanced rotorcraft airframes. Attention is given to U.S. Army requirements for fatigue integrity, the reconstruction of helicopter loads spectra, the damage-tolerance evaluation of sandwich shear panels, the impact resistance of graphite/PEEK composites, advanced composite energy-absorbing cabin subfloor structures, NASTRAN evaluations of honeycomb sandwich panels, V-22 structural analyses, an integral composite driveshaft and its coupling, and the application of advanced winding technology to the V-22 Osprey tilt-rotor. O.C.

A89-30554

ECONOMIC ISSUES IN COMPOSITES MANUFACTURING

RICHARD M. MCLANE (Boeing Commercial Airplanes, Seattle, WA) IN: American Society for Composites, Technical Conference, 3rd, Seattle, WA, Sept. 25-29, 1988, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1988, p. 23-32.

An evaluation of the development history of commercial aircraft control-surface structures' manufacturing with polymer-matrix composite materials notes that little verifiable data is available for a definitive comparison of composites' economics with those of the metallic structures they supplant. Composite components whose fabrication can be automated furnish the best basis for comparison, and encompass such cases as rotor blades and filament-wound pressure vessels. Although manufacturing automation capabilities have been expanding, they must be complemented with careful economic management and direct control by structural designers. O.C.

A89-30646#

ASPECTS OF MILITARY-AIRCRAFT DEVELOPMENT UP TO THE YEAR 2000 [PROBLEMY ROZWOJU SAMOLOTOW WOJSKOWYCH DO 2000 R.]

JANUSZ PERLINSKI Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, July 1988, p. 5-8. In Polish.

Advanced design concepts for military aircraft are examined. Particular attention is given to developments in the following areas: aerodynamics, engine design and performance, structural design and construction materials, and stealth aircraft technology. B.J.

A89-30881#

COMPOSITE MATERIAL REPAIRS TO METALLIC AIRFRAME COMPONENTS

T. F. CHRISTIAN, JR., D. O. HAMMOND (USAF, Warner Robins Air Logistics Center, Robins AFB, GA), and J. B. COCHRAN (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 2172-2179. refs

(AIAA PAPER 89-1408)

The feasibility of using composite materials for repair of aluminum structures on the C-141B aircraft is discussed. The selection of candidate locations, configuration and materials for repairs, and the analytical evaluation of the repairs for structural adequacy and durability is covered. Four repairs are installed on a static test article, two repairs are installed on in-service aircraft, and one on a pylon. The material evaluation shows the most suitable applications to be graphite/epoxy and boron/epoxy composites. The material processes evaluation shows that a proprietary structural film adhesive provides the needed durability and strength at 80 C (180 F) cure temperature. The simple surface treatment consisting of surface abrasion followed by A-187 silane treatment is effective for boron/epoxy and graphite/epoxy systems. The concept of using composites to repair metal structures is determined to be feasible. S.A.V.

A89-31421
HIGH SPEED COMMERCIAL FLIGHT: FROM INQUIRY TO ACTION; PROCEEDINGS OF THE SECOND SYMPOSIUM, COLUMBUS, OH, OCT. 19, 20, 1988
JAMES P. LOOMIS, ED. (Battelle Center for High Speed Commercial Flight, Columbus, OH) Symposium sponsored by Battelle Memorial Institute. Columbus, OH, Battelle Press, 1989, 223 p. No individual items are abstracted in this volume.

The current development status of high-speed commercial transport aircraft is surveyed and analyzed by industry and government experts, with an emphasis on economic and policy implications. Sections are devoted to aircraft research and development, operations and markets, consortia and financing, and institutional considerations. Diagrams and graphs are provided, as well as an executive summary and summaries of the discussion at the symposium. T.K.

A89-32100#
70 YEARS OF TRANSPORT AIRCRAFT DEVELOPMENT - WHAT DID THE AIRLINES LEARN?
ERNST H. SIMON AIAA, Annual Meeting and Exhibit, Arlington, VA, May 2-4, 1989. 8 p.
(AIAA PAPER 89-1641)

The development of civil transport aircraft from the early beginnings to the present is reviewed, with emphasis on the role that the airlines have played in bringing aircraft technology to its present state. Consideration is given to the mistakes which have been frequently made by both airlines and manufacturers, and to what should be done to avoid them. The benefits that can be derived from a capable airline engineering department are considered. B.J.

N89-18407*# California State Polytechnic Univ., Pomona. Dept. of Aerospace Engineering.
THE FLYING DIAMOND: A JOINED AIRCRAFT CONFIGURATION DESIGN PROJECT, VOLUME 1 Final Report, 1987 - 1988
CHRIS BALL, JOE CZECH, BRYAN LENTZ, DARYL KOBASHIGAWA, CURTIS OISHI, and DAVID POLADIAN 11 Jun. 1988 119 p
(Contract NGT-21-002-080)
(NASA-CR-184699; NAS 1.26:184699) Avail: NTIS HC A06/MF A01 CSCL 01B

The results of the analysis conducted on the Joined Wing Configuration study are presented. The joined wing configuration employs a conventional fuselage and incorporates two wings joined together near their tips to form a diamond shape in both plan view and front view. The arrangement of the lifting surfaces uses the rear wing as a horizontal tail and as a forward wing strut. The rear wing has its root at the tip of the vertical stabilizer and is structurally attached to the trailing edge of the forward wing. This arrangement of the two wings forms a truss structure which is inherently resistant to the aerodynamic bending loads generated during flight. This allows for a considerable reduction in the weight of the lifting surfaces. With smaller internal wing structures needed, the Joined Wing may employ thinner wings which are more suitable for supersonic and hypersonic flight, having less induced drag than conventional cantilever winged aircraft. Inherent in the Joined Wing is the capability of the generation of direct lift and side force which enhance the performance parameters. NASA

N89-18408*# California State Polytechnic Univ., Pomona.
WAVERIDER, VOLUME 2 Final Report, 1987 - 1988
PAT NIGHTINGALE, TOAN DUONG, CHRIS GILLOTTE, RON MANGIO, and PABLO MARTINEZ 11 Jun. 1988 115 p
(Contract NGT-21-002-080)
(NASA-CR-184700; NAS 1.26:184700) Avail: NTIS HC A06/MF A01 CSCL 01B

The results of a study concerning a High-Speed Civilian Transport Aircraft are discussed. An evaluation of the viability of four configurations is presented. One design considered in the Waverider configuration. The Waverider creates lift at high speeds through the use of shock waves. This shocklift when combined with conventionally created lift provides high lift/drag values at higher speeds than conventional configurations. The Waverider cruises at Mach 5.5, has a range of 6,500 nautical miles, and seats 250 passengers. The aircraft is operable from existing airfields and does not require any special traffic control considerations when operating in controlled airspace. NASA

N89-18409*# California State Polytechnic Univ., Pomona. Dept. of Aerospace Engineering.
THE HORIZON: A BLENDED WING AIRCRAFT CONFIGURATION DESIGN PROJECT, VOLUME 3 Final Report, 1987 - 1988
PAUL KEIDEL, MARK GONDA, DARNON FREEMAN, JAY KIM, and YUL HSU 11 Jun. 1988 101 p
(Contract NGT-21-002-080)
(NASA-CR-184701; NAS 1.26:184701) Avail: NTIS HC A06/MF A01 CSCL 01B

The results of a study to design a High-Speed Civilian Transport (HSCT) using the blended wing-body configuration are presented. The HSCT is a Mach 2 to 5 transport aircraft designed to compete with current commercial aircraft. The subjects discussed are sizing, configuration, aerodynamics, stability and control, propulsion, performance, structures and pollution effects. NASA

N89-18410*# California State Polytechnic Univ., Pomona. Dept. of Aerospace Engineering.
THE LEADING EDGE 250: OBLIQUE WING AIRCRAFT CONFIGURATION PROJECT, VOLUME 4 Final Report, 1987 - 1988
ANDRE SCHMIDT, PERI MOORE, DAN NGUYEN, PETROS OGANESYAN, and CHARLES PALMER 11 Jun. 1988 71 p
(Contract NGT-21-002-080)
(NASA-CR-184702; NAS 1.26:184702) Avail: NTIS HC A04/MF A01 CSCL 01B

The design of a high speed transport aircraft using the oblique wing concept as a part of the High Speed Civil Transport (HSCT) aircraft study is the Leading Edge 250 capable of travelling at Mach 4 with 250 passengers and has a 6,500 nautical mile range. Its innovation lies within its use of the unconventional oblique wing to provide efficient flight at any Mach number. Wave drag is kept to a minimum at high speed, while high lift is attained during critical takeoff and landing maneuvers by varying the sweep of the wing. NASA

N89-18411*# California State Polytechnic Univ., Pomona. Dept. of Aerospace Engineering.
CONDOR: LONG ENDURANCE HIGH ALTITUDE VEHICLE, VOLUME 5 Final Report, 1987 - 1988
L. CULLEN ANDREWS, BILL AUGSBURGER, THOMAS COTE, MIHAEL GHITEA, IL SIK LEE, SUSIK LEE, and GARY LEONG 11 Jun. 1988 108 p
(Contract NGT-21-002-080)
(NASA-CR-184703; NAS 1.26:184703) Avail: NTIS HC A06/MF A01 CSCL 01B

The results of a design study resulting in the proposed CONDOR aircraft are presented. The basic requirements are for the aircraft to maintain continuous altitude at or above 45,000 feet for at least a 3-day mission, be able to comfortably support a two-man crew during this period with their field of vision not obstructed to a significant degree, carry a payload of 200 pounds, and provide a power supply to the payload of 2000 watts. The take-off and landing distances must be below 5000. feet, and time to reach cruise altitude must not exceed 3 hours. The subjects discussed are configuration selection, structural analysis, stability and control, crew and payload accomodations, and economic estimates. NASA

N89-19226# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
ESTIMATING AIRCRAFT AIRFRAME TOOLING COST: AN ALTERNATIVE TO DAPCA 3 M.S. Thesis
PATRICIA L. MEYER Sep. 1988 89 p

(AD-A201506; AFIT/GCA/LSQ/88S-6) Avail: NTIS HC A05/MF A01 CSCL 01C

The purpose of this study was to evaluate the tooling cost estimating equation of the DAPCA 3 model and determine if more accurate models can be developed. The five objectives of the research were: (1) Determine the accuracy of the DAPCA 3 model; (2) Determine if the independent variables in DAPCA 3 are logically valid; (3) Determine if the data base which was used to develop DAPCA 3 is appropriate for estimating today's aircraft systems; (4) Determine if the accuracy of the DAPCA 3 model can be improved; and (5) Determine if using a factor of manufacturing is sufficient to estimate tooling costs. When tooling was regressed against manufacturing and engineering, the data without the prototypes indicated that engineering was more significant than manufacturing. Both manufacturing and engineering were significant for the data with the prototypes. GRA

N89-19228# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Systems and Logistics.

R AND M (RELIABILITY AND MAINTAINABILITY) QUALITY TEAM CONCEPT AND C-17 DESIGN AT DOUGLAS AIRCRAFT COMPANY: AN R AND M 2000 INITIATIVE CASE STUDY M.S. Thesis

R. ANTHONY PHILLIPS Sep. 1988 89 p

(AD-A201574; AFIT/GLM/LSM/88S-56) Avail: NTIS HC A05/MF A01 CSCL 05A

The Aeronautical Systems Divisions's C-17 System Program Office has developed a quality management initiative called the R and M (Reliability and Maintainability) Quality Team Concept. Its purpose is to provide companies with better management of R and M during the full-scale engineering development acquisition phase. Douglas Aircraft Co. (DAC) agreed to implement the R and M Quality Team Concept during design of the C-17. This thesis examined the effect of the R and M Quality Team Concept as instituted by DAC on the quality management of the R and M process during C-17 design. Research assessed the concept's perceived impact on: (1) communication on R and M issues; (2) R and M problem solving; and (3) specific C-17 design changes. A survey was administered to DAC employees and interviews were conducted with management at DAC's Long Beach, CA, facility. Hypothesis testing using z and t-tests assisted in evaluating survey results. Study results revealed overall employee support for the R and M Quality Team Concept. The concept provided a method of R and M management and problem solving not available in a traditional program organization, and a number of C-17 design changes resulted from concept application. GRA

N89-19229# Transportation Systems Center, Cambridge, MA.

GENERAL AVIATION ACTIVITY AND AVIONICS SURVEY Annual Summary Report, CY 1987

MICHAEL A. ROSSETTI Nov. 1988 289 p

(AD-A201760; DOT-TSC-FAA-88-6; FAA-MS-88-5) Avail: NTIS HC A13/MF A01 CSCL 01D

The results and a description of the 1987 General Aviation Activity and Avionic Survey are presented. The survey was conducted during 1988 by the FAA to obtain information on the activity and avionics of the United States registered general aviation aircraft fleet, the dominant component of civil aviation in the U.S. The survey was based on a statistically selected sample of about 11.1 percent of the general aviation fleet. A response rate of 61.1 percent was obtained. Survey results are based upon responses but are expanded upward to represent the total population. Survey results revealed that during 1987 an estimated 33.4 million hours of flying time were logged and 93.7 million operations were performed by the 217,183 active general aviation aircraft in the U.S. fleet. The mean annual flight time per aircraft was 148.4 hours. The active aircraft represented about 81.2 percent of the registered general aviation fleet. The report contains breakdowns of these and other statistics by manufacturer/model group, aircraft type, state and region of based aircraft, and primary use. Also included are fuel consumption, lifetime airframe hours, avionics, engine hours, and miles flown estimates, tables for detailed analysis of the avionics capabilities of the GA (General Aviation) fleet. GRA

N89-19230*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1987

FREDERICK R. MORRELL, comp. Apr. 1989 118 p Presented at a conference held in Atlantic City, NJ, 14-15 Jan. 1988

(NASA-CP-3028; L-16547; NAS 1.55:3028) Avail: NTIS HC A06/MF A01 CSCL 01B

The research conducted during 1987 under the NASA/FAA sponsored Joint University Program for Air Transportation Research is summarized. The Joint University Program is a coordinated set of 3 grants sponsored by NASA-Langley and the FAA, one each with the MIT, Ohio Univ., and Princeton Univ. Completed works, status reports, and annotated bibliographies are presented for research topics, which include computer science, guidance and control theory and practice, aircraft performance, flight dynamics, and applied experimental psychology. An overview of the year's activities for each university is also presented. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A89-29162*# High Technology Corp., Hampton, VA.

SHEARED WING-TIP AERODYNAMICS - WIND-TUNNEL AND COMPUTATIONAL INVESTIGATION

P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), C. P. VAN DAM (California, University, Davis), and B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 207-213. refs

Computational and experimental performance benefits are presented for a high-aspect-ratio unswept wing configuration with sheared tips. The sheared tip is a highly swept and highly tapered surface located in the same plane as the inboard wing panel to which it is attached. The compuational results were obtained with an inviscid surface panel method that models the nonlinear influence of the trailing wake. Both wind-tunnel and calculated results were obtained for a 12-ft span wing model with various wing-tip configurations. The computational and experimental data are in fair agreement and demonstrate that sheared wing tips can reduce induced drag at cruise and climb lift coefficients. The drag reduction is the result of wake deformation effects and changes in spanwise load distribution. Wind-tunnel measured longitudinal and lateral directional stability characteristics are also presented for the various wing-tip layouts. Author

A89-29163#

ANALYSIS OF WINGS WITH FLOW SEPARATION

TUNCER CEBECI, K. C. CHANG, R. W. CLARK (Douglas Aircraft Co., Long Beach, CA), and D. SEDLOCK (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 214-220. refs (Contract F33615-83-C-3026)

An interactive viscous/inviscid procedure has been developed combining a three-dimensional panel method with an inverse finite-difference boundary-layer method. The scheme incorporates both a two-dimensional and a quasi-three-dimensional boundary-layer scheme. The resulting method has been applied to the calculation of the flow over three-dimensional wings and wing/body configurations, and it has been shown that the procedure can compute flows with significant regions of boundary-layer separation. Author

A89-29165#
TRAILING-EDGE REGION OF AIRFOILS
B. E. THOMPSON (Scientific Research Associates, Inc., Glastonbury, CT) and J. H. WHITELAW (Imperial College of Science and Technology, London, England) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 225-234. refs

Measured and calculated results obtained in a set of trailing-edge flows are examined to consolidate understanding of the requirements and implications for airfoil calculation methods. The experiments investigated sharp, round, and blunt trailing edges, attached and separated turbulent boundary layers, and boundary-layer interaction with the wake of an airfoil on the suction side. Emphasis is placed on higher angles of attack and on the consequences of flow separation. A combination of inviscid-flow calculations, interactive boundary-layer calculations with equations in integral and differential form, and Reynolds-averaged Navier-Stokes calculations have been used to confirm conclusions based on these experiments and to assess implications for approximations. The measurements suggest, and calculations confirm, that streamwise and normal momentum equations need to be solved in calculations of trailing-edge flows and that, in particular, normal pressure gradients and turbulence normal stresses need to be represented. Turbulence production from Reynolds normal stresses can exceed turbulence shear stress production in a separated flow, and this has implications for turbulence models. The ability to calculate contributions to lift and drag is considered within the trailing-edge region, and the experimental and computational uncertainties incurred in the results are examined. Author

A89-29166*# Planning Research Corp., Hampton, VA.
FULL-POTENTIAL ANALYSIS OF A SUPERSONIC DELTA WING/BODY
O. J. ROSE (Planning Research Corp., Hampton, VA), DAVID S. MILLER, JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA), P. R. ASHILL, and J. L. FULKER (Royal Aircraft Establishment, Bedford, England) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 235-240. Previously cited in issue 07, p. 936, Accession no. A88-22355. refs

A89-29167#
FLOW OVER AN AIRFOIL WITH JETS
YURII A. KRASSIN Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 241-246. refs

The flow over an airfoil with jets is considered in two cases: where the Bernoulli constants of the jets and freestream are equal, and where they are different. The first case concerns entering jets and the second escaping jets. Complex variables are used. In the first case, the flow is represented by a source-vortex singularity at the airfoil. In the second, vortex sheets on the jet boundaries are added to the previous system. Vortex strengths are defined by the vertical jet momentum and source strengths by the horizontal jet momentum. Simple equations are obtained for the jet lift augmentation, which depends on the total heads of the jet and the freestream, the initial jet angle, jet momentum flux, and jet flow rate. These parameters can be chosen to be optimum for minimal takeoff and landing distances. Author

A89-29168#
EFFECT OF ROUGHNESS ON ROLLUP OF TIP VORTICES ON A RECTANGULAR HYDROFOIL
J. KATZ (Johns Hopkins University, Baltimore, MD) and J. BUENO GALDO Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 247-253. Research supported by the U.S. Navy. refs

Experiments focusing on the development of a tip vortex on a rectangular NACA-66 hydrofoil have been performed in towing tank. The study consists of flow visualization by illumination with a laser sheet and by distributing fluorescing dye in the water. It also includes surface pressure measurements, particularly around the tip. The observations demonstrate that the physical dimensions of the tip vortex are not affected significantly by the surface roughness, whereas the surface pressure, particularly just under the tip vortex, changes substantially. This observation leads to the conclusion that an increase in the surface roughness reduces the strength of the tip vortex. The flow visualization experiments also demonstrate that for all the roughness sizes, the tip vortex dimensions increase with the incidence angle and decrease as the velocity is increased. In addition, the study demonstrates that the flow is unsteady and that the tip region is dominated by multiple secondary vortex structures. A series of sample photographs demonstrating these phenomena is provided. Author

A89-29169#
NONLINEAR AERODYNAMICS OF A DELTA WING IN COMBINED PITCH AND ROLL
J. ER-EL, D. WEIHS (Technion - Israel Institute of Technology, Haifa), and D. SETER (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 1852-1858) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 254-259. Previously cited in issue 03, p. 261, Accession no. A89-13688. refs

A89-29184*# California Univ., Los Angeles.
TIME DOMAIN UNSTEADY INCOMPRESSIBLE CASCADE AIRFOIL THEORY FOR HELICOPTER ROTORS IN HOVER
M. A. H. DINYAVARI and P. P. FRIEDMANN (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 27, March 1989, p. 257-267. refs
(Contract NAG2-209)

A detailed derivation of a finite-time arbitrary-motion incompressible cascade theory is presented for both Laplace and frequency domains. The generalized cascade lift deficiency function is shown to be consistent with the generalized Theodorsen's lift deficiency function when the wake spacing approaches infinity or when the reduced frequency tends to infinity; it also yields a correct value for the zero reduced frequency limit. Efficient numerical procedures are presented for the evaluation of the cascade lift deficiency function. Numerical examples comparing the cascade lift deficiency function with Loewy's (1957) rotary-wing lift deficiency function in frequency domain are presented. Pade approximants of the cascade lift deficiency function are constructed using a Bode plot approach that allows for complex poles. A general-purpose optimization program is used to determine the coefficients of the approximant. Author

A89-29186*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VISCOUS DRAG REDUCTION OF A NOSE BODY
PROMODE R. BANDYOPADHYAY (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, March 1989, p. 274-282. Previously cited in issue 07, p. 928, Accession no. A88-22096. refs
(Contract NAS1-18235)

A89-29192#
INTERACTION OF JET IN HYPERSONIC CROSS STREAM
J. S. SHANG, D. L. MCMASTER, N. SCAGGS, and M. BUCK (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 27, March 1989, p. 323-329. refs

A jet stream issuing normally from both sharp- and blunt-nose ogive-cylinder configurations into a hypersonic flow was investigated by a side-by-side experimental and numerical simulation. At a hypersonic Mach number of 12, strong interaction between jet-induced and bow shock wave systems, the jet plume trajectory, and the separated-flow surface shear pattern were highlighted for basic understanding. After the numerical solution was verified with the experimental data, the flowfield topology was reconstructed. Several unique features of this inviscid-viscous interaction phenomenon of shock-wave formation, vortical flow structure, and jet plume were delineated. Author

A89-29204#
FLOW PHENOMENA COMMON TO AERONAUTICAL AND NAVAL DOMAINS
H. WERLE (ONERA, Chatillon-sous-Bagneux, France)

(International Conference on Technology Common to Aero and Marine Engineering, London, England, Jan. 26-28, 1988) ONERA, TP, no. 1988-8, 1988, 15 p. refs
(ONERA, TP NO. 1988-8)

Low Reynolds number water tunnel tests have been conducted with a variety of simple models in order to observe such isolated fundamental phenomena as unseparated flow, boundary layer transitions and separation, vortices, and wake flows, as well as their interactions in the cases of more complex models representative of missiles, aircraft, and submarines. The perspective of these efforts has been the degree of commonality between hydrodynamic flow phenomena encountered in marine vehicles and aerodynamic phenomena encountered in aircraft. Attention is given to vortex-shedding characteristics at extreme angles-of-attack; Reynolds numbers were in all cases below 5000. O.C.

A89-29208#
TRANSPORT AIRCRAFT INTAKE DESIGN
JACKY LEYNAERT (ONERA, Chatillon-sous-Bagneux, France) (Institut von Karman de Dynamique des Fluides, Lecture Series, Brussels, Belgium, Feb. 22-26, 1988) ONERA, TP, no. 1988-18, 1988, 28 p. refs
(ONERA, TP NO. 1988-18)

The present discussion of recent developments in the design of transport aircraft engine air intakes gives attention to supersonic cruise powerplant shock-recovery inlets designed for operation in the Mach 2.5-3.0 range, as well as the projection of possible inlet configurations for hypersonic cruise aircraft. Critical design problems are noted to be posed by (1) inlet sensitivity to flight-control disturbances, and (2) variable-geometry features adapting the powerplant to either efficient subsonic or supersonic operation. The configurational solutions embodied in the Concorde engine nacelle inlets, and the Mach-3.0 cruise inlets of the XB-70 bomber and SR-71 high-altitude reconnaissance aircraft, are studied for their noteworthy details. O.C.

A89-29232#
RECENT BASIC STUDIES ON TRANSONIC SHOCK-WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
J. DELERY (ONERA, Chatillon-sous-Bagneux, France) (IUTAM, Symposium Transsonicum, 3rd, Goettingen, Federal Republic of Germany, May 24-27, 1988) ONERA, TP, no. 1988-54, 1988, 22 p. refs
(ONERA, TP NO. 1988-54)

Results are presented from three fundamental studies of transonic interacting flows aimed at the definition of test cases for the validation of theoretical predictions. These studies concern (1) turbulence modeling in two-dimensional shock-induced interactions, (2) the structure of three-dimensional channel flow, and (3) passive control of a shock-induced interaction in two-dimensional channel flow. The structure of the flow resulting from shock-induced interactions in a three-dimensional transonic channel is far more complex than that of a nominally two-dimensional interaction; the skin-friction line patterns reveal a complex topology containing a large number of singularities and separation lines. O.C.

A89-29243#
TRANSONIC COMPUTATIONS BY MULTIDOMAIN TECHNIQUES WITH POTENTIAL AND EULER SOLVERS
PH. MORICE (ONERA, Chatillon-sous-Bagneux, France) (IUTAM, Symposium Transsonicum, 3rd, Goettingen, Federal Republic of Germany, May 24-27, 1988) ONERA, TP, no. 1988-78, 1988, 13 p. refs
(ONERA, TP NO. 1988-78)

Some multidomain techniques are presented for the solution of potential and Euler transonic flows on multiblocked grids. The method for the transonic full potential calculations is founded on a substructured preconditioned conjugate gradient solution of linear subproblems in a finite element approximation. The Euler multiblock solution follows from an adaptation of characteristic relations to the treatment of interfaces for an upwind implicit linearized ADI noniterative scheme. A coupling of a potential and of an Euler solver permits the three-dimensional calculation of a supersonic jet in a transonic outer flow with fitting of the jet surface. Author

A89-29263#
VISCOUS-INVISCID STRATEGY AND COMPUTATION OF TRANSONIC BUFFET
J. C. LE BALLEUR and P. GIRODROUX-LAVIGNE (ONERA, Chatillon-sous-Bagneux, France) (IUTAM, Symposium Transsonicum, 3rd, Goettingen, Federal Republic of Germany, May 24-27, 1988) ONERA, TP, no. 1988-111, 1988, 12 p. Research supported by the Service Technique des Programmes Aeronautiques. refs
(ONERA, TP NO. 1988-111)

After summarizing the viscous-inviscid strategy and the progress in nonboundary-layer formulations and in numerical coupling techniques, an interacting time-dependent thin-layer method is presented and shown to be capable of computing time-consistently the transonic buffet over airfoils. The method approximates the defect formulation theory with a modeling of the instantaneous viscous velocity profiles, and fully recovers the viscous upstream influence from a time-consistent viscous-inviscid coupling, converged at each time-step. Results are shown both for a supercritical airfoil and a NACA0012 airfoil. The computed buffet-onset and buffet time-evolutions are compared with available experiments, versus incidence and Mach number. Author

A89-29264#
TRANSONIC DEGENERACY IN SYSTEMS OF CONSERVATION LAWS
J.-P. GUIRAUD (Paris VI, Universite; ONERA, Chatillon-sous-Bagneux, France) (IUTAM, Symposium Transsonicum, 3rd, Goettingen, Federal Republic of Germany, May 24-27, 1988) ONERA, TP, no. 1988-112, 1988, 11 p. refs
(ONERA, TP NO. 1988-112)

The problem of degeneracy in conservation laws for transonic aerodynamics is investigated analytically. Equations for the simplest type of degeneracy in conservation laws, for systems in two independent variables, and for a more generalized case in three dimensions are obtained, and the relationships between the present asymptotic derivations and more conventional formulations are explored. T.K.

A89-29276#
COMPUTATION OF HIGH REYNOLDS NUMBER FLOWS AROUND AIRFOILS BY NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS
J. P. VEUILLOT and L. CAMBIER (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Numerical Methods in Fluid Dynamics, 11th, Williamsburg, VA, June 27-July 1, 1988) ONERA, TP, no. 1988-124, 1988, 6 p. refs
(ONERA, TP NO. 1988-124)

The turbulent flows around the NACA0012 airfoil are calculated by solving the Reynolds-averaged Navier-Stokes equations with eddy viscosity turbulence models. The equations are derived from the Navier-Stokes equations by replacing the energy equation with the steady Bernoulli relation. The calculations are performed in three C-meshes using the turbulence models of Michel et al. (1969), Baldwin and Lomax (1978), and Jones and Launder (1972). R.B.

A89-29281#
AN ITERATION TECHNIQUE COUPLING 3-D TRANSONIC SMALL PERTURBATION AERODYNAMIC THEORY AND ROTOR DYNAMICS IN FORWARD FLIGHT
C. T. TRAN and A. DESOPPER (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1988-130, 1988, 19 p. refs
(ONERA, TP NO. 1988-130)

The aerodynamic loading and stress states of a helicopter rotor blade in forward flight are characterized by means of numerical computations, using the SA349GV Gazelle at 262 and 290 km/h as an example. The rotor-disk flowfield is treated using an unsteady three-dimensional small-disturbance finite-difference code (Chattot, 1980), and the dynamic response of the blade is modeled in terms of second-order linearized differential equations with periodic coefficients; these approaches are then coupled using the iterative procedure of Dat and Tran (1986) and Dat (1987). The numerical results are compared with experimental data in extensive graphs. It is concluded that, although the use of three-dimensional aerodynamic theory does not produce significant improvements over a two-dimensional quasi-steady model for the present rectangular blade, such improvements should be realized for advanced blade-tip shapes. T.K.

A89-29282#

A NEW COMPUTATIONAL METHOD APPLIED TO ACCELERATION POTENTIAL THEORY

J.-J. COSTES and G. HARDY (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1988-131, 1988, 19 p. refs

(ONERA, TP NO. 1988-131)

In aerodynamics, integral methods are well suited for the study of complex aeroelastic problems. However, the singularities of the functions which are integrated need to be treated very carefully. This paper shows an application of the acceleration potential theory for the helicopter. The blade is schematized by a set of lifting lines, and a nonseparation condition of the flow from the blade surface is written on collocation points. The treatment of the mathematical singularities which occur when a lifting line passes on a collocation point is detailed. The theory has been validated by comparison with a wind tunnel test. Predictions were also made for the Gazelle helicopter rotor. Author

A89-29283#

AIR INLETS AND AFTERBODIES OF SUBSONIC AND SUPERSONIC AIRCRAFT ENGINES - GENERAL ASPECTS [LES PRISES D'AIR ARRIERE-CORPS DE MOTEUR DES AVIONS SUBSONIQUES ET SUPERSONIQUES - ELEMENTS GENERAUX]

J. LEYNAERT (Colloque d'Aerodynamique Appliquee, 25th, Talence, France, Oct. 12-14, 1988) ONERA, TP, no. 1988-132, 1988, 83 p. In French. refs

(ONERA, TP NO. 1988-132)

The design principles of air inlets and afterbodies for subsonic and supersonic aircraft engines are discussed, with special attention given to the physical significance of parameters such as steady and unsteady distortion and the adaptation of air inlets and nozzles to the flight Mach number. Results are presented for subsonic-cruise aircraft, large-incidence combat aircraft, and supersonic-cruise aircraft at Mach 2 and 3. Also considered are variable-cycle engines, the application of bypasses, and geometric adaptations to angle of incidence and side slip. R.R.

A89-29679

THE DELAY OF TURBULENT BOUNDARY LAYER SEPARATION BY OSCILLATORY ACTIVE CONTROL

Y. KATZ, B. NISHRI, and I. WYGNANSKI (Tel Aviv University, Israel) Physics of Fluids A (ISSN 0899-8213), vol. 1, Feb. 1989, p. 179-181. refs

(Contract AF-AFOSR-86-0323)

The flow outside a solid wedge that abruptly diverges at an angle of 18 deg was investigated experimentally. A turbulent boundary layer, which separated at the discontinuity and turned into a mixing layer downstream of it, reattached as a result of harmonic excitation at the apex of the wedge. Preliminary results indicate that this might be an effective way to delay separation of turbulent and laminar boundary layers. Author

A89-29756#

OPTIMUM NON-SLENDER GEOMETRIES OF REVOLUTION FOR MINIMUM DRAG IN FREE-MOLECULAR FLOW WITH GIVEN ISOPERIMETRIC CONSTRAINTS

S. C. JAIN (Defence Science Centre, Delhi, India) Defence Science Journal (ISSN 0011-748X), vol. 38, April 1988, p. 183-190. refs

The problem of determining the optimum nonslender bodies of revolution in free molecular flow is addressed for specified isoperimetric constraints, namely, for a given surface area and volume of the body while the diameter and length are free. If normalized coordinates are used, optimum shapes for a given shape parameter are blunt nosed. As the shape parameter increases, the value of the drag coefficient decreases; in the case of hypersonic flow, it increases. K.K.

A89-29924*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THREE DIMENSIONAL VISCOUS ANALYSIS OF A HYPERSONIC INLET

D. R. REDDY, G. E. SMITH, M.-F. LIOU (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Middleburg Heights, OH), and T. J. BENSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 27th, Reno, NV, Jan. 9-12, 1989. 8 p. Previously announced in STAR as N89-16759. refs

(AIAA PAPER 89-0004)

The flow fields in supersonic/hypersonic inlets are currently being studied at NASA Lewis Research Center using 2- and 3-d full Navier-Stokes and parabolized Navier-Stokes solvers. These tools have been used to analyze the flow through the McDonnell Douglas Option 2 inlet which has been tested at Calspan in support of the National Aerospace Plane Program. Comparisons between the computational and experimental results are presented. These comparisons lead to better overall understanding of the complex flows present in this class of inlets. The aspects of the flow field emphasized in this work are the 3-D effects, the transition from laminar to turbulent flow, and the strong nonuniformities generated within the inlet. Author

A89-30070

A MODEL OF SELF-OSCILLATION GENERATION FOR AERODYNAMIC CONTROL SURFACES AT TRANSONIC VELOCITIES [MODEL' VOZNIKNOVENIIA AVTOKOLEBANII AERODINAMICHESKIKH POVERKHNOSTEI UPRAVLENIIA NA OKOLOZVUKOVYKH SKOROSTIAKH]

A. V. SAFRONOV (Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Jan. 1989, p. 111, 112. In Russian.

The paper is concerned with nonseparated transonic gas flow with shock waves past a thin symmetric airfoil with an oscillating control surface. Based on an analysis of the Prandtl-Mayer flow and the dynamic curvature hypothesis, the possibility of the generation of excitation hinge moments in the transonic flow due to the interaction of shock waves with oscillating aerodynamic control surfaces is demonstrated. Analytical expressions are obtained which characterize the interaction of shock waves with oscillating aerodynamic control surfaces; a graphic interpretation of these expressions is presented. V.L.

A89-30106

THREE-DIMENSIONAL RAREFIED-GAS FLOW PAST CONICAL BODIES [PROSTRANSTVENNOE OBTEKANIE KONICHESKIKH TEL POTOKOM RAZREZHENNOGO GAZA]

I. N. LARINA and V. A. RYKOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Jan. 1989, p. 110-117. In Russian.

A first-order numerical method is proposed for solving the problem of the three-dimensional rarefied-gas flow past conical bodies at high Mach numbers, assuming the surface of the body to be cold. The introduction of a special coordinate system makes it possible to construct an algorithm for solving the problem with registration of the distribution function in the entire flow field. Calculation results are presented for an elliptical cone at angle of attack. B.J.

A89-30108

VORTEX GENERATION IN COMPUTATIONAL AERODYNAMICS [O VIKHREOBRAZOVANII V VYCHISLITEL'NOI AERODINAMIKE]

A. A. GLADKOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Jan. 1989, p. 135-137. In Russian.

The paper examines the possible reason for changes in flow vorticity and the generation of vortex structures near wing leading edges at high angles of attack as reflected in the inexact satisfaction of the Friedmann equation and of the conditions of the Helmholtz and Thomson theorems in the numerical solution of the Euler equations. It is found that vorticity changes in real flows may be due to the physical fluctuations of the flow parameters. B.J.

A89-30109
DIRECT CALCULATION OF FLOWS WITH SHOCK WAVES [K 'SKVOZNOMU' SCHETU TECHENII S UDARNYMI VOLNAMI]
A. N. KRAIKO, A. R. POLIANSKII, and N. I. TILLIAEVA Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Jan. 1989, p. 137-142. In Russian. refs
Two aspects of the direct calculation of flows with shock waves are considered. First, two promising difference schemes of decay type (the Godunov-Kolgan scheme and the TVD) are compared. Second, requirements are defined for choosing a difference grid for methods involving the automatic transition to marching calculation in supersonic-flow subdomains. B.J.

A89-30110
THREE-DIMENSIONAL SUPERSONIC FLOWS PAST BLUNT BODIES WITH ALLOWANCE FOR INTERFERENCE [O SVERKHZVUKOVOM PROSTRANSTVENNOM OBTEKANII ZATUPLENNYKH TEL S UCHETOM INTERFERENTSII]
A. A. ANDREEV and A. S. KHOLODOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Jan. 1989, p. 142-147. In Russian. refs
Attention is given to the numerical solution of the problem of the supersonic three-dimensional flow of an inviscid non-heat-conducting gas past a blunt body. A grid/characteristics method is used to solve the gasdynamic equations. Calculations results are presented for flow past spherical bodies. B.J.

A89-30205
SUPERSONIC LAMINAR BOUNDARY LAYER BEHIND A FAN OF RAREFACTION WAVES [SVERKHZVUKOVOI LAMINARNYI POGRANICHNYI SLOI ZA VEEROM VOLN RAZREZHENIIA]
A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Dec. 1988, p. 18-23. In Russian. refs
A supersonic laminar boundary layer formed in the case of flow past an external blunt corner is investigated experimentally, with attention given to both mean flow parameters (longitudinal flow velocity profiles, Mach number at the outer boundary, and boundary layer thickness) and flow stability against natural perturbations. Results of tests conducted in a supersonic wind tunnel indicate that the turning of the supersonic laminar boundary layer over the blunt corner leads to flow stabilization, which is in qualitative agreement with the conclusions of a precious theoretical study (Gaponov and Petrov, 1987). V.L.

A89-30216
SUPERSONIC FLOWS OF A VISCOUS GAS [SVERKHZVUKOVYE TECHENIIA VIAZKOGO GAZA]
VALERII I. TIMOSHENKO Kiev, Izdatel'stvo Naukova Dumka, 1987, 184 p. In Russian. refs
The book is concerned with various aspects of supersonic flows of a viscous gas past bodies. In particular, attention is given to the principal equations of viscous gas dynamics, generalized conditions of viscous-nonviscous interaction, problems of interaction between a nonviscous boundary layer with an external supersonic flow, and high-density viscous flows past bodies in the wake of a shock wave. Other topics covered include the viscous shock layer and simplified Navier-Stokes equations, hypersonic flow past thin bodies, parameter calculation in supersonic local separation zones, and two-phase flow past bodies. V.L.

A89-30250
EXCITATION OF UNSTABLE OSCILLATIONS IN A BOUNDARY LAYER BY A SOURCE IN THE POTENTIAL FLOW REGION [VOZBUZHDENIE NEUSTOICHIVYKH KOLEBANII V POGRANICHNOM SLOE ISTOCHNIKOM V POTENTSIAL'NOI OBLASTI TECHENIIA]
O. S. RYZHOV (AN SSSR, Vychislitel'nyi Tsentr, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 304, no. 4, 1989, p. 820-824. In Russian. refs
The problem of the susceptibility of the boundary layer to external perturbations of different types is investigated analytically for the case where the source is located in the potential flow region, which is typical of many wind tunnel experiments. Potential flow of a fluid is determined from a solution to a boundary value problem for the Laplace equation. The solution obtained here reveals the mechanisms by which unstable oscillations are excited in the boundary layer by a source located in the potential flow region. V.L.

A89-30479#
BEHAVIOUR OF INTERNAL MANIPULATORS - 'RIBLET' MODELS IN SUBSONIC AND TRANSONIC FLOWS
E. COUSTOLS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 15 p. Research supported by Service Technique des Programmes Aeronautiques and Airbus Industrie. refs
(AIAA PAPER 89-0963)
An evaluation is conducted of the low-subsonic and transonic regime efficacy of riblet device-based drag reduction methods, with a view to the effects of such internal manipulators on the mean and fluctuating quantities of a two-dimensional turbulent boundary layer. Wind tunnel tests on airfoils equipped with riblet surfacings show these devices to maintain their beneficial effect in adverse pressure gradients whose intensity depends on the airfoil's angle-of-attack. Transonic results are found to exhibit 7-8 percent drag reductions, which are comparable to the low-subsonic results. O.C.

A89-30486#
SEPARATION CONTROL USING MOVING SURFACE EFFECTS - A NUMERICAL SIMULATION
A. A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ) and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 10 p. refs
(AIAA PAPER 89-0972)
Numerical simulations of the laminar and/or turbulent flows past modified NACA0012 and NACA63-218 airfoils having leading-edge rotation are carried out for a wide range of angles of attack, leading-edge rotation speeds, and free-stream Mach numbers. An implicit finite-difference procedure is employed to solve the two-dimensional compressible full Reynolds-averaged Navier-Stokes equations on a body-fitted curvilinear coordinate system. Particular attention is given to the effects of varying the leading-edge circumferential speed (or the strength of the introduced forebody vorticity) on the location(s) of the points of laminar and/or turbulent separation on the airfoil's surfaces, the size of the separated flow regions, the predicted sectional lift forces, and the location and strength of shock waves for supercritical free-stream Mach numbers. K.K.

A89-30487#
CONTROL OF FLOW SEPARATION BY ACOUSTIC EXCITATION
M. NISHIOKA, M. ASAI, and S. YOSHIDA (Osaka Prefecture, University, Sakai, Japan) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 10 p. refs
(AIAA PAPER 89-0973)
An attempt is made to control leading-edge flow separation on an airfoil by means of acoustic excitation. Particular attention is given to the incident sound and resulting flow instability in the case of a flat-plate airfoil at a chord Reynolds number of 40,000.

Due to its sharp leading edge, a clear separation bubble is observed at an angle of attack of 2 deg. The shear layer is shown to be highly unstable; it amplifies small disturbances into discrete vortices. K.K.

A89-30488#

CONTROL OF WALL-SEPARATED FLOW BY INTERNAL ACOUSTIC EXCITATION

FEI-BIN HSIAO, CHIN-FUNG LIU, JONG-YAW SHYU, and MUH-RONG WANG (National Cheng Kung University, Tainan, Republic of China) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 10 p. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-76-0401-E006-21)
(AIAA PAPER 89-0974)

The use of the internal acoustic excitation technique to control wall-separated flow on a NACA 63(3)-018 airfoil and a circular cylinder is discussed. Particular attention is given to changes in the pressure distribution, lift, and drag with respect to the excitation level, and to the excitation frequency, and excitation location. It is found that the enhancement of the flow mixing and momentum transport, due to internal excitation, produces a 'suction peak' at the leading edge of the upper-surface airfoil. K.K.

A89-30489#

THE DELAY OF TURBULENT BOUNDARY LAYER SEPARATION BY OSCILLATORY ACTIVE CONTROL

Y. KATZ (Tel Aviv University, Israel; Arizona, University, Tucson), B. NISHRI, and I. WYGNANSKI (Tel Aviv University, Israel) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 9 p. refs
(Contract AF-AFOSR-86-0323)
(AIAA PAPER 89-0975)

The flow over a solid wedge from which a fully developed turbulent boundary layer separates naturally is studied experimentally. It is found that the introduction of harmonic two-dimensional oscillations results in a reattachment of the flow and changes the proportions between the 'wake' and 'wall' functions whose linear combination represents the streamwise velocity distribution in a turbulent boundary layer. The two-dimensional forcing enhances the span of the coherent structures near the solid surface. K.K.

A89-30495*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

EFFECT OF WALL SUCTION ON THE STABILITY OF COMPRESSIBLE SUBSONIC FLOWS OVER SMOOTH TWO-DIMENSIONAL BACKWARD-FACING STEPS

AYMAN A. AL-MAAITAH, ALI H. NAYFEH, and SAAD A. RAGAB (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 10 p. refs
(Contract N00014-85-K-0011; NAG1-714)
(AIAA PAPER 89-0983)

The effect of suction on the stability of compressible flows over backward-facing steps is investigated. Mach numbers up to 0.8 are considered. The results show that continuous suction stabilizes the flow outside the separation bubble, but it destabilizes the flow inside it. Nevertheless, the overall N factor decreases as the suction level increases due to the considerable reduction of the separation bubble. For the same suction flow rate, properly distributed suction strips stabilize the flow more than continuous suction. The size of the separation bubble, and hence its effect on the instability can be considerably reduced by placing strips with high suction velocities in the separation region. Author

A89-30498#

EFFECTS OF A FILLET ON THE FLOW PAST A WING BODY JUNCTION

W. J. DEVENPORT, M. B. DEWITZ, N. K. AGARWAL, R. L. SIMPSON, and K. PODDAR (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 12 p. refs
(Contract N00014-88-C-0291)
(AIAA PAPER 89-0986)

Measurements are presented to demonstrate the effects of a simple fillet on the flow of a turbulent boundary layer past an idealized wing-body junction. The time-averaged flow structure in the vicinity of the wing and in the wake of the wing-body junction are considered, as well as the unsteadiness of the horseshoe vortex. The effects of angle of attack and approach boundary layer thickness are also examined. Author

A89-30501*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LAMINAR FLOW - THE PAST, PRESENT, AND PROSPECTS

R. D. WAGNER, D. W. BARTLETT (NASA, Langley Research Center, Hampton, VA), and F. S. COLLIER, JR. (High Technology Corp., Hampton, VA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 22 p. refs
(AIAA PAPER 89-0989)

Flight research conducted on natural laminar flow (NLF) is discussed. Emphasis is on recent flight testing conducted by the National Aeronautics and Space Administration. To place these flight experiences in perspective, important flight tests from the early days of natural laminar flow research are first reviewed to recall the lessons learned at that time. Then, based on more recent flight experiences and analyses with state-of-the-art boundary layer stability theory, speculation is made on the possibility of extensive NLF on swept wing transport aircraft. Author

A89-30508#

GENERATION AND CONTROL OF SEPARATED VORTICES OVER A DELTA WING BY MEANS OF LEADING EDGE FLAPS

T. KARAGOUNIS, T. MAXWORTHY, and G. R. SPEDDING (Southern California, University, Los Angeles) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 18 p. refs
(Contract AF-AFOSR-85-0318)
(AIAA PAPER 89-0997)

A series of experiments have been conducted to investigate the ability of leading edge flaps to generate and control separated vortices of enhanced strength over a delta wing. The flaps project towards the suction side, with inclinations ranging from being folded on the wing's upper surface to being perpendicular to it. Flaps of 7.5 and 5 deg apex angle were tested on a wind tunnel model equipped with pressure taps. Tests were run for both static and rapidly opening/closing flaps. Complementary flow visualization tests were carried out in a water channel. At zero and low angles of attack of the main wing, the flap generates and controls a strong, separated vortex that generates significantly more lift than the wing alone. At high incidence, the vortex enhancement and control capabilities are lost. Asymmetric opening of one flap is effective for rolling moment control only at the lowest angles of attack. Rapid opening of the flaps can result, temporarily, in much stronger vortices and suction peaks. Author

A89-30510#

CONTROL OF LEADING-EDGE VORTICES ON A DELTA WING

C. MAGNESS, O. ROBINSON, and D. ROCKWELL (Lehigh University, Bethlehem, PA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 19 p. Research supported by USAF. refs
(AIAA PAPER 89-0999)

A study was conducted of the varying degrees of phase-shift observable between the onset of vortex development and vortex breakdown as the angle-of-attack of a pitching delta wing was varied through such classes of ramp-motion as pitch-up, pitch-down, continuous pitch-up and -down, and combinations of ramp-pitching rates. The results obtained suggest that the functional form of the pitching maneuver, the phase-shift of the vortex breakdown, can be optimized to optimize the loading on the wing. Attention was also given to the analogous forcing and response of vortex breakdown on a stationary wing. O.C.

A89-30514#

THE SCALING AND CONTROL OF VORTEX GEOMETRY BEHIND PITCHING CYLINDERS

R. E. MONTIVIDAS, P. REISENTHEL, and H. N. NAGIB (Illinois Institute of Technology, Chicago) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 13 p. refs
(Contract F49620-86-C-0133)
(AIAA PAPER 89-1003)

The behavior of the flowfield behind a circular cylinder/conical nose configuration has been studied over a wide range of angles of attack, considering both steady and single sweep pitching conditions for a range of Reynolds numbers, based on diameter, from 2700-11,000. Flow visualization techniques are used to determine the scaling properties of the swept cylinder and to establish flow regime maps. The asymmetric wake pattern was manipulated using passive devices such as a pair of trapezoidal wings and sets of symmetrically disposed winglets. R.R.

A89-30519#

A PROGRESS REPORT ON ACTIVE CONTROL OF FLOW INSTABILITIES - ROTATING STALL STABILIZATION IN AXIAL COMPRESSORS

J. DUGUNDJI, A. H. EPSTEIN, V. GARNIER, E. M. GREITZER, G. GUENETTE (MIT, Cambridge, MA) et al. AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 8 p. Research supported by USAF and U.S. Navy. refs
(AIAA PAPER 89-1008)

This paper gives a summary of the progress made in controlling instabilities in aeromechanical systems during the past eighteen months. The specific test bed used in this study is the broad class of instability phenomena generic to propulsion and pumping systems. The aim of the paper is to present, in broad brush, an overview of the research that has been carried out and a description of the approaches used. The interdisciplinary aspects of the work, which we feel are a key part of the program, are also brought out. Author

A89-30533#

CONTROL OF THE UNSTEADY, SEPARATED FLOW BEHIND AN OSCILLATING, TWO-DIMENSIONAL FLAP

CURTIS F. NELSON, DENNIS J. KOGA, and JOHN K. EATON (Stanford University, CA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 12 p. refs
(Contract AF-AFOSR-86-0159)
(AIAA PAPER 89-1027)

Methods for the passive and active open-loop control of the unsteady separated flow produced downstream of a two-dimensional lifting flap are considered. Although the unsteady vortex was not affected by passive control (due to the fixed separation line of the flap), significant increases in the pressure recovery were found for the steady separation. Active control by pulsed blowing and suction was shown to reduce the suction peak of the unsteady vortex by as much as 40 percent and to delay the peak suction by 14 ms. R.R.

A89-30537

LARGE AMPLITUDE OSCILLATION EFFECTS ON CONE PITCH STABILITY IN VISCOUS HYPERSONIC FLOW

G. R. HUTT, R. A. EAST, and R. D. WILSON (Southampton, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 93, Feb. 1989, p. 50-57. Research supported by the Ministry of Defence Procurement Executive. refs

A pointed and an 0.2-bluntness ratio 10-deg semiangle cone conducting pitching oscillations in hypersonic (Mach 6.85) flow has yielded experimental and theoretical small/large-amplitude stability data. An analysis of these data indicates that large-amplitude model-motion time histories cannot be predicted on the basis of small-amplitude oscillation stability derivatives data. At the Re numbers studied, the pointed and the blunted cone are subject to substantial viscous flow phenomena; these are proposed to be the bases of large-amplitude stability predictions' invalidity. O.C.

A89-30765*# PRC Systems Services Co., Hampton, VA.

SUPERSONIC FAR-FIELD BOUNDARY CONDITIONS FOR TRANSONIC SMALL-DISTURBANCE THEORY

MICHAEL D. GIBBONS (PRC Systems Services, Hampton, VA) and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1085-1093. refs
(AIAA PAPER 89-1283)

Characteristic far-field boundary conditions for supersonic freestream flow have been developed and implemented within a transonic small-disturbance code. The boundary conditions have been implemented within the CAP-TSD code which has been developed recently for aeroelastic analysis of complete aircraft configurations. These boundary conditions improve the accuracy of the solutions for supersonic freestream applications. They also allow the extent of the grid to be much smaller, thus providing savings in the computational time required to obtain solutions. Comparisons are shown between surface pressures computed using large and small grid extents for the NACA 0012 airfoil and the F-5 wing at various Mach numbers and angles of attack. Both steady and unsteady results are presented and comparisons are made with Euler results and with experimental data to assess the accuracy of the new far-field boundary conditions. Comparisons of these results show that the supersonic boundary conditions allow a much smaller grid to be used without losing accuracy. Author

A89-30766#

A VORTEX PANEL METHOD FOR THE SOLUTION OF INCOMPRESSIBLE UNSTEADY FLOW

K. ROKHSAZ, B. P. SELBERG, and W. EVERSMAN (Missouri-Rolla, University, Rolla) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1094-1104. refs
(AIAA PAPER 89-1284)

A vortex panel method is presented for the solution of incompressible unsteady aerodynamic problems for lifting surfaces with finite thickness. The accuracy and robustness of the method is demonstrated through comparisons with the existing numerical data and independent test cases. Also, through numerous examples, the flexibility of this method in handling different types trailing edge shapes and multiple interfering geometries is shown. Furthermore, the method is used to analyze the effects of airfoil thickness on aerodynamic coefficients of multielement lifting systems. It is shown that although the influence of thickness is negligible for single element airfoils, it can be profound for closely coupled airfoils and slotted flaps. Author

A89-30767#

EFFECTS OF THREE DIMENSIONAL AERODYNAMICS ON BLADE RESPONSE AND LOADS

KI-CHUNG KIM and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1105-1118. refs
(Contract DAAL03-88-C-002)
(AIAA PAPER 89-1285)

A comprehensive rotor analysis based on finite element theory in space and time is coupled with a three-dimensional transonic small disturbance finite difference analysis to investigate three-dimensional aerodynamic effects on blade response and loads in forward flight. Each blade is assumed to undergo flap bending, lag bending, elastic twist and axial deflections. The blade response is calculated from nonlinear periodic normal mode equations using a finite element in time scheme. For induced inflow distributions on the rotor disk, a free wake model is used. Dynamic stall and reverse flow effects are also included. Vehicle trim and rotor elastic response are calculated as one coupled solution using the Newton method. The blade response and loads are calculated for two blade configurations: a straight-tip blade and a 30 deg swept-back tip blade. Calculated results are correlated with flight test data obtained from the Gazelle helicopter (with a straight-tip blade) for two level flight speeds. Results then are calculated for this rotor with a swept-tip configuration and the effects of three-dimensional aerodynamics are assessed. Considerable three-dimensional aerodynamic effects are observed in the swept-tip blade. Author

A89-30796#

STATE-SPACE MODEL FOR UNSTEADY AIRFOIL BEHAVIOR AND DYNAMIC STALL

J. GORDON LEISHMAN (Maryland, University, College Park) and GILBERT L. CROUSE, JR. IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1372-1383. Research supported by the U.S. Army. refs

(AIAA PAPER 89-1319)

A time-domain model has been formulated to represent, at an engineering level of approximation, the unsteady lift, drag and pitching moment characteristics of a two-dimensional airfoil undergoing dynamic stall. The model is given as a set of first order differential state equations; (1) an eight state linear attached flow solution derived from indicial response functions valid for compressible flow, (2) a three state solution for the progressive nonlinear effects of trailing edge flow separation and, (3) a single state solution for the catastrophic leading edge flow separation which is characteristic of dynamic stall. The dynamics of each part of the model are coupled in such a way to allow progressive transition between the airfoil static stall and the dynamic stall characteristics. An important feature of the model is that the effects of flow compressibility are included and as such the method is particularly useful in the performance, aeroelastic response, and real-time simulation analysis of helicopter rotors. To validate the model, correlations are presented with unsteady force and moment data from oscillatory pitch tests on NACA 0012, HH-02 and SC-1095 airfoils. Author

A89-30799#

A HYBRID DOUBLET LATTICE-DOUBLET POINT METHOD FOR GENERAL LIFTING SURFACE CONFIGURATIONS IN SUBSONIC FLOW

WALTER EVERSMAN (Missouri-Rolla, University, Rolla) and DALE M. PITT (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1407-1416. refs

(AIAA PAPER 89-1322)

A shortcoming and problem with the original formulation of subsonic Doublet Point Method has been identified. This shortcoming is the inability to model aerodynamic strips of unequal width on a lifting surface. The inability of the original doublet point method to handle nonplanar and intersecting surfaces is also discussed. A hybrid scheme has been developed with the best features of the Double Point and Doublet Lattice Methods combined. The hybrid code has no geometry restrictions, i.e., it will handle unequal strip widths and nonparallel intersecting surfaces. The application of this hybrid code to test cases show an increase in computational efficiency with no degradation of accuracy. Author

A89-30800#

A TIME DOMAIN PANEL METHOD FOR WINGS

M. BLAIR (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and M. H. WILLIAMS (Purdue University, West Lafayette, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1417-1426. refs

(AIAA PAPER 89-1323)

A computer algorithm and FORTRAN code have been developed to simulate a time history of aerodynamic loads on planar lifting surfaces using the subsonic linearized potential integral formulation of Guderley. This work is intended for application to the simulation of flexible wing motion with active controls. In this paper, the method is validated by examining the indicial responses of two wings. The results are transformed to the frequency domain and compared to the results of a frequency domain doublet lattice code H7WC. Author

A89-30952* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLUCTUATIONS AND MASSIVE SEPARATION IN THREE-DIMENSIONAL SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS

M. I. KUSSOY (NASA, Ames Research Center; Eloret Institute, Moffett Field, CA), J. D. BROWN, J. L. BROWN, W. K. LOCKMAN, and C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) IN: Transport phenomena in turbulent flows: Theory, experiment, and numerical simulation; Proceedings of the Second International Symposium, Tokyo, Japan, Oct. 1987. New York, Hemisphere Publishing Corp., 1988, p. 875-887. Previously announced in STAR as N88-18559. refs

Shock-wave unsteadiness was observed in rapidly compressed supersonic turbulent boundary layer flows with significant separation. A Mach 2.85 shock-wave/turbulent boundary layer flow was set up over a series of cylinder-flare bodies in the High Reynolds Number Channel 1. The transition from fully attached to fully separated flow was studied using axisymmetric flares with increasing compression angles. In the second phase, the 30-deg flare was inclined relative to the cylinder axis, so that the effect on a separated flow of increasing three-dimensionality could be observed. Two 3-D separated cases are examined. A simple conditional sampling technique is applied to the data to group them according to an associated shock position. Mean velocities and turbulent kinetic energies, computed from the conditionally sampled data, are compared to those from the unsorted data and to computed values. Three basic questions were addressed: can conditional sampling be used to provide snapshots of the flow; are averaged turbulence quantities dominated by the bimodal nature of the interaction; and is the shock unsteadiness really important to computational accuracy. Author

A89-31327* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STABILITY AND TRANSITION IN SUPERSONIC BOUNDARY LAYERS

GORDON ERLEBACHER and M. YOUSUFF HUSSAINI (NASA, Langley Research Center, Hampton, VA) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 387-398. refs

The three-dimensional time-dependent, compressible Navier-Stokes equations are numerically solved by a Fourier-Chebyshev collocation algorithm to study the stability of a Mach 4.5 flow over a flat plate. Several nonlinear direct simulations suggest the existence of a secondary instability which might provide a possible route to transition. Pertinent differences in the energy content of the various Fourier modes between this instability and the more common incompressible K-type instabilities are pointed out. Author

A89-31343* JAI Associates, Mountain View, CA.

NAVIER-STOKES SIMULATIONS OF TIP VORTICES FOR FIXED AND ROTATING HELICOPTER BLADES

G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA) and W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: Computational fluid dynamics; Proceedings of the International

Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 651-662. refs
(Contract DAAG29-85-C-0002)

Flowfield and tip vortex results are presented for a hovering rotor blade at subcritical and supercritical flow conditions for both nonlifting and lifting configurations. These results are calculated numerically by solving, in a time-accurate fashion, the unsteady thin layer Navier-Stokes equations written in rotor coordinates. The lifting calculations use an induced downwash correction, estimated from a free wake analysis, to the geometric angle of attack of the blades to account for the wake effect. Comparison of numerical results with the experimental data shows very good agreement for all cases considered. Alternate methods of calculating hovering rotor flowfield as steady state flowfield on isolated fixed-blade that have the same circulation distribution as that of rotor in hover are also explored. Author

A89-31351

NUMERICAL SIMULATION OF INCOMPRESSIBLE FLOW AROUND THREE-DIMENSIONAL WING

MICHIRU YASUHARA and YOSHIAKI NAKAMURA (Nagoya University, Japan) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 785-792. refs

A viscous incompressible flow solver with third-order convective term differencing written in generalized three-dimensional coordinates was applied to a three-dimensional wing flow at a Reynolds number of 170,000 with a nonuniform 61 x 30 x 25 grid to analyze the generation of a wing-tip vortex. A large-tip vortex was also simulated. The complex flow pattern on the wing surface was elucidated by the oil flow and pressure contours. K.K.

A89-31362*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

VORTICAL FLOW COMPUTATIONS ON SWEPT FLEXIBLE WINGS USING NAVIER-STOKES EQUATIONS

GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989. 13 p. refs
(AIAA PAPER 89-1183)

A procedure to couple the Navier-Stokes solutions with modal structural equations of motion is presented for computing aeroelastic responses of swept flexible wings. The Navier-Stokes flow equations are solved by a finite-difference scheme with dynamic grids. The coupled aeroelastic equations of motion are solved using the linear-acceleration method. The configuration-adaptive dynamic grids are time-accurately generated using the aeroelastically deformed shape of the wing. The calculations are compared with the experiment when available. Effects of flexibility, sweep angle, and pitch rate are demonstrated for flows with vortices. Author

A89-31512#

COMPUTATIONS OF THE HYPERSONIC FLOW BY THE SPECTRAL METHOD

MICHIRU YASUHARA, YOSHIAKI NAKAMURA, and JIAN-PING WANG Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 419, 1988, p. 542-549. In Japanese, with abstract in English. refs

A numerical calculation code based on the Fourier-Chebyshev spectral collocation method is developed to solve the three-dimensional Euler equations at the hypersonic flow regime. The governing equations are transformed to generalized coordinates in order to treat a body of arbitrary shape. As examples, a sphere and the forward part of a Shuttle-type body were calculated at free-stream Mach numbers 4 and 8. The present results show good agreement with other numerical and analytical results and experiments, in spite of the small number of grid points. Author

A89-31517#

STUDY ON UNSTEADY FLOW FIELD OF AN OSCILLATING CASCADE

XIJIU SUN and WEIWEI ZHANG (Tsinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Nov. 1988, p. 320-326. In Chinese, with abstract in English. refs

A research method and experimental results on the unsteady aerodynamic characteristics of a group of turbine blades tested in a subsonic oscillating cascade wind tunnel are described. The influence of various incidence angles and different interblade phase angles on the unsteady aerodynamic characteristics of an oscillating cascade is addressed. The distribution of oscillating pressures on the blade surface and the velocity field inside the passage are measured using an X-type hot-film probe. The data are used to analyze the stability of the oscillating cascade. It is found that, whether the oscillation is simple harmonic or not, the base frequency component of the oscillating pressure occupies an absolute governing position. The stability of an oscillating cascade is greatly affected by the interblade phase and incidence angles. C.D.

A89-31519#

A GENERAL THEORY OF HYBRID PROBLEMS FOR FULLY 3-D COMPRESSIBLE POTENTIAL FLOW IN TURBOROTORS. II - AXIAL FLOW, POTENTIAL FUNCTION FORMULATION

GAOLIAN LIU, KANGMIN CHEN, and ZHENG YAO (Shanghai Institute of Mechanical Engineering, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Nov. 1988, p. 331-333. In Chinese, with abstract in English. refs

A89-31520#

VARIATIONAL FINITE ELEMENT CALCULATION FOR HYBRID CASCADE FLOW PROBLEM OF TYPE-A ON AN ARBITRARY STREAM SHEET

ZHENG YAO, YUELIN CHEN, and QISHENG GUO (Shanghai Institute of Mechanical Engineering, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Nov. 1988, p. 334-337. In Chinese, with abstract in English. refs

A new calculation method for cascade design and/or modification is developed based on a variational principle and the finite element method. The method permits the boundary condition along a blade surface to be composed of different parts. On some part of the airfoil contour, only the velocity distribution is prescribed, while along the remaining part only the contour geometry is given. This method combines the advantages of both the direct and the inverse problems, thereby providing a flexible and effective approach to cascade design. The method has been applied to calculations of the blade profile of axial and centrifugal cascades, with satisfactory results. C.D.

A89-31522#

EFFECTS OF FREE-STREAM TURBULENCE ON PERFORMANCE OF SUBSONIC DIFFUSER

LIANGWEI FANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 9, Nov. 1988, p. 342-346. In Chinese, with abstract in English. refs

The effect of free-stream turbulence on the performance of the subsonic diffuser has been studied experimentally. The experimental result shows that the free-stream turbulence affects substantially the pressure recovery of the diffuser and that the isotropic and anisotropic free-stream turbulences have a different extent of effect on the pressure recovery. Author

A89-31806#

NUMERICAL SIMULATION OF UNSTEADY THREE-DIMENSIONAL FLOWS IN TURBINES [SIMULATION NUMERIQUE DES ECOULEMENTS TRIDIMENSIONNELS ET INSTATIONNAIRES DANS LES TURBOMACHINES]

ANTOINE FOURMAUX, GILLES BILLONNET, and GEORGES MEAUZE (SFM, Journees d'Etude, Paris, France, Oct. 12, 13,

1988) ONERA, TP, no. 1988-145, 1988, 17 p. In French. refs
(ONERA, TP NO. 1988-145)

Various approaches to the simulation of unsteady viscous three-dimensional flows in gas turbines are discussed. Stream-surface warping through the blade row is simulated by computing the stream surface geometry and then analyzing the blade-to-blade flow on the stream surfaces. Modifications are made to the Euler method in order to model viscous effects. The various methods are demonstrated with examples including the modeling of transient phenomena in axial gas turbines. R.R.

A89-31807#

RESEARCH CONDUCTED AT THE ONERA DIRECTION DE L'AERODYNAMIQUE FOR CALCULATING INTERNAL FLOWS BY SOLUTION OF THE EULER AND NAVIER-STOKES EQUATIONS [RECHERCHES MENEES A LA DIRECTION DE L'AERODYNAMIQUE DE L'ONERA POUR LE CALCUL D'ECOULEMENTS INTERNES PAR RESOLUTION DES EQUATIONS D'EULER OU DE NAVIER-STOKES]

L. CAMBIER, J. P. VEUILLOT, and A. M. VUILLOT (ONERA, Chatillon-sous-Bagneux, France) (SFM, Journees d'Etude, Paris, France, Oct. 12, 13, 1988) ONERA, TP, no. 1988-146, 1988, 27 p. In French. Research supported by DRET and SNECMA. refs
(ONERA, TP NO. 1988-146)

Aerodynamic flows in turbine engines are investigated, solving the Euler equations to obtain a perfect-fluid model, and solving the time-averaged Navier-Stokes equations to obtain a viscous-fluid model. The Euler model is shown to accurately calculate rotational flows and reproduce the shock wave positions predicted using the Rankine-Hugoniot relations. The Navier-Stokes model provides an acceptable description of the dissipative wall and wake boundaries. R.R.

A89-31810#

CALCULATION OF INVISCID NOZZLE FLOW IN THERMAL AND CHEMICAL NONEQUILIBRIUM [CALCUL D'ECOULEMENT NON VISQUEUX DANS UNE TUYERE AVEC DESEQUILIBRES THERMIQUE ET CHIMIQUE]

P. SAGNIER and L. MARRAFFA (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1988-150, 1988, 57 p. In French. refs
(ONERA, TP NO. 1988-150)

A numerical study has been conducted to model the inviscid flow in thermal and chemical nonequilibrium of a hypersonic R6 nozzle. It is shown that the Park coupling (1986, 1988) model does not accurately predict the behavior of this nozzle. The various vibrational, electronic, and chemical kinetic models employed are found to yield similar results, despite differences in the type and kinetics of the reactions considered. R.R.

A89-31811#

COMPARISON OF TEST MOUNTS FOR MILITARY AIRCRAFT AFTERBODIES [COMPARAISON DE MONTAGES D'ESSAIS D'ARRIERE-CORPS D'AVIONS MILITAIRES]

M. LYONNET, P. HUGOUVIEUX, and J. P. LEDY ONERA, TP, no. 1988-151, 1988, 38 p. In French. refs
(ONERA, TP NO. 1988-151)

Two test mounts for the wind tunnel study of military aircraft afterbody drag are evaluated. The single-mast mount, supporting the model upstream, is found to provide better results for subsonic and transonic flows, while the double-mast, supporting the model at the wing extremities, is more appropriate for supersonic flows. Single-mast tests were performed at the S2MA wind tunnel, and external drag results obtained from global weights as a function of the nozzle jet expansion rates were found to agree well with those obtained using pressure integrations. R.R.

A89-31813#

EXPERIMENTAL STUDY OF THE FLOW IN AN AIR INTAKE AT ANGLE OF ATTACK [ETUDE EXPERIMENTALE DE L'ECOULEMENT DANS UNE PRISE D'AIR EN INCIDENCE]

J. R. BION, D. CERONI, J. P. TOBELI (ONERA, Chatillon-sous-Bagneux, France), and R. VOYEZ (ONERA, Modane, France) ONERA, TP, no. 1988-154, 1988, 34 p. In French. Research supported by DRET. refs
(ONERA, TP NO. 1988-154)

An experimental apparatus has been developed to monitor the flow in an air intake at all points from the upstream side to the compressor entrance. The apparatus is used in conjunction with a CCD camera (to perform visualizations), a five-hole probe (to determine the local velocity components and modulus), and a hot-wire probe (to study the turbulence parameters in the presence and absence of internal separation). Results are presented for an air intake at large angles of attack. R.R.

A89-31817#

VELOCITY MEASUREMENTS IN SUBSONIC AND TRANSONIC FLOWS [LA MESURE DES VITESSES DANS LES ECOULEMENTS SUBSONIQUES ET TRANSSONIQUES]

A. BOUTIER (ONERA, Chatillon-sous-Bagneux, France) (Exposition Internationale Mesure-Controle-Regulation-Automatisme, Congres, Paris, France, Nov. 14-18, 1988) ONERA, TP, no. 1988-159, 1988, 33 p. In French. refs
(ONERA, TP NO. 1988-159)

The performances of fringe velocimeters and optical barrier velocimeters in measuring velocities in subsonic and transonic flows are evaluated and compared. Fringe velocimeters can simultaneously measure the three components of the local instantaneous velocity vector and determine the total Reynolds tensor. Optical barrier velocimeters are well suited for studying turbine engines under conditions of strong parasitic light and weakly turbulent flow, and their SNR is higher than that of fringe laser velocimeters. R.R.

A89-31857#

INVESTIGATION OF THE PARALLEL BLADE-VORTEX INTERACTION AT LOW SPEED

D. D. SEATH, JAI-MOO KIM, and D. R. WILSON (Texas, University, Arlington) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 328-333. Previously cited in issue 18, p. 2808, Accession no. A87-42402. refs
(Contract DAAG29-84-K-0131)

A89-31867*# Douglas Aircraft Co., Inc., Long Beach, CA.

INTERACTIVE BOUNDARY-LAYER CALCULATIONS OF A TRANSONIC WING FLOW

KALLE KAUPS, TUNCER CEBECI (Douglas Aircraft Co., Long Beach, CA), and UNMEEL MEHTA (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 397-400. Research supported by the Douglas Aircraft Independent Research and Development Program. refs

Results obtained from iterative solutions of inviscid and boundary-layer equations are presented and compared with experimental values. The calculated results were obtained with an Euler code and a transonic potential code in order to furnish solutions for the inviscid flow; they were interacted with solutions of two-dimensional boundary-layer equations having a strip-theory approximation. Euler code results are found to be in better agreement with the experimental data than with the full potential code, especially in the presence of shock waves, (with the sole exception of the near-tip region). O.C.

A89-31901#

PRESSURE AND FLOW FIELD CALCULATION IN SUPERSONIC AND HYPERSONIC FLOW ABOUT ROUNDED BODIES

V. N. CONSTANTINESCU and S. DANAILA (Institutul Politehnic, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 33, Sept.-Oct. 1988, p. 423-437. refs

An improved version of Telenin's (1956) method is used to compute the flow about a rounded nose body in supersonic and hypersonic regimes. The improvements are designed to increase the accuracy of the numerical derivatives and to speed up the convergence of the iteration procedure. The present procedure was implemented in the form of FORTRAN programs on a CORAL 4011 minicomputer. Both axisymmetric and two-dimensional flows were analyzed. K.K.

A89-31910#
FLUCTUATION OF HEAT TRANSFER IN SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTION
MASANORI HAYASHI, SHIGERU ASO (Kyushu University, Fukuoka, Japan), and ANZHONG TAN AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 399-404. Previously cited in issue 07, p. 935, Accession no. A88-22318. refs

A89-31914*# Old Dominion Univ., Norfolk, VA.
COMPUTATIONS OF SUPERSONIC FLOWS OVER A BODY AT HIGH ANGLES OF ATTACK
O. BAYSAL, K. FOULADI (Old Dominion University, Norfolk, VA), and D. S. MILLER (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 427-437. Previously cited in issue 07, p. 936, Accession no. A88-22360. refs
(Contract NAG1-664)

A89-31916# Purdue Univ., West Lafayette, IN.
OSCILLATING INCOMPRESSIBLE AERODYNAMICS OF A LOADED AIRFOIL CASCADE
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 446-454. Research sponsored by USAF and NASA. Previously cited in issue 07, p. 933, Accession no. A88-22242. refs

A89-31917#
DESIGN OF AIRFOILS AND CASCADES OF AIRFOILS
THEODOSIOS P. KORAKIANITIS (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 455-461. Research supported by the General Electric Co. Previously cited in issue 20, p. 3144, Accession no. A87-45451. refs

A89-31918#
COMPUTATIONAL AERODYNAMICS OF OSCILLATING CASCADES WITH THE EVOLUTION OF STALL
F. SISTO, WENQUAN WU, S. THANGAM (Stevens Institute of Technology, Hoboken, NJ), and S. JONNAVITHULA AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 462-471. Previously cited in issue 20, p. 3143, Accession no. A87-45383. refs
(Contract N00014-86-K-0315)

A89-32145
POSSIBILITIES FOR MODELING TURBULENT HEAT TRANSFER IN HYPERSONIC FINITE-JET FLOW PAST BODIES [VOZMOZHNOSTI MODELIROVANIIA TURBULENTNOGO TEPLOOBMENA PRI GIPERZVUKOVOM OBTEKANII TEL V STRUIAKH OGRANICHENNOGO RAZMERA]
IU. V. POLEZHAEV and IU. N. SHISHKIN (AN SSSR, Institut Vysokikh Temperatur, Moscow, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 27, Jan.-Feb. 1989, p. 104-108. In Russian. refs

An analysis of the interaction of jets of finite size with blunt bodies makes it possible to determine the limiting dimensions of the models being tested and the range of parameters corresponding to maximum Reynolds numbers for given pressure and temperature in the precombustion chamber. The effect of comoving flow on flow stability against separation and on the accuracy of pressure distribution modeling is examined. The possibility of obtaining turbulent Reynolds numbers in the case of supersonic finite-jet flow past blunt bodies is confirmed experimentally. V.L.

A89-32197
GASDYNAMIC STRUCTURE OF THE QUASI-STEADY SEPARATED FLOW OF DIFFERENT GASES IN A PLANE SUPERSONIC NOZZLE [O GAZODINAMICHESKOI STRUKTURE KVAZISTATSIONARNOGO OTRYVNOGO TECHENIIA RAZLICHNYKH GAZOV V PLOSKOM SVERKHZVUKOVOM SOPLE]
B. M. DOBRYNIN, V. G. MASLENNIKOV, and V. A. SAKHAROV (AN SSSR, Fiziko-Tekhnicheskii Institut, Leningrad, USSR) Zhurnal Tekhnicheskoi Fiziki (ISSN 0044-4642), vol. 58, Dec. 1988, p. 2390-2392. In Russian.

A shock-tube study of quasi-steady separated flows of different gases in supersonic wedge-shaped nozzles was carried out. Based on the experimental results, a simplified model of separated flow in a wedge-shaped nozzle is proposed. The dependence of Mach number at the separation point on the pressure ratio is evaluated. B.J.

A89-32279
DIRECT STATISTICAL MODELING OF FLOW OF A RAREFIED GAS PAST A SPHERE IN THE TRANSITION REGIME [PRIAMOE STATISTICHESKOE MODELIROVANIE OBTEKANIIA SFERY RAZREZHENNYM GAZOM V PEREKHODNOM REZHIME]
K. V. NIKOLAEV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 29, Feb. 1989, p. 263-269. In Russian. refs

A version of the weight method of statistical modeling is proposed for modeling axisymmetric hypersonic flow of a rarefied gas past a blunt body. Integral and distributed aerodynamic and thermal characteristics of flow of a monoatomic gas past a sphere are obtained for Reynolds numbers equal to or less than 100. The use of statistical weights makes it possible to control the accuracy of calculations in different regions of the flow field. V.L.

A89-32301*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TOWARD LOWER DRAG WITH LAMINAR FLOW TECHNOLOGY
W. D. HARVEY and P. J. BOBBITT (NASA, Langley Research Center, Hampton, VA) ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Paper. 21 p. refs

The most promising method of achieving significantly lower skin-friction drag of an aircraft component is through the stabilization and maintenance of a laminar boundary layer over a large fraction of its surface. In a number of applications, however, laminar flow is unfeasible and/or undesirable, and the most efficient turbulent flow design must be provided. The development of both laminar and turbulent airfoil and wing designs over the past decade is reviewed. High, medium, and low-speed airfoil concepts are discussed, and some overall comparisons are made for different Reynolds number ranges. S.A.V.

A89-32315*# Cincinnati Univ., OH.
3-D COMPOSITE VELOCITY SOLUTIONS FOR SUBSONIC/TRANSONIC FLOWS
R. E. GORDNIER and S. G. RUBIN (Cincinnati, University, OH) Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 4th, University of California, Long Beach, Jan. 18-23, 1989, Paper. 12 p. refs
(Contract F49620-85-C-0027; NAG1-8)

A composite velocity procedure for the three-dimensional reduced Navier-Stokes equations is developed. In the spirit of matched asymptotic expansions, the velocity components are written as a combination multiplicative and additive composite of viscouslike velocities and pseudopotential or inviscid velocities. The solution procedure is then consistent with both asymptotic inviscid flow and boundary layer theory. For transonic flow cases, the Enquist-Osher flux biasing scheme developed for the full potential equation is used. A quasi-conservation form of the governing equations is used in the shock region to capture the correct rotational shock with the standard nonconservation form of the equations used in nonshock regions. The consistent coupled strongly implicit procedure coupled with a plane relaxation procedure is used to solve the discretized equations. Author

A89-32331*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA SUPERCRITICAL LAMINAR FLOW CONTROL AIRFOIL EXPERIMENT
W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) CASI, Annual General Meeting on Conserving Energy in Air Transport, 29th, Toronto, Canada, May 4, 5, 1982, Paper. 97 p. refs

The design and goals of experimental investigations of supercritical LFC airfoils conducted in the NASA Langley 8-ft Transonic Pressure Tunnel beginning in March 1982 are reviewed. Topics addressed include laminarization aspects; flow-quality requirements; simulation of flight parameters; the setup of screens, honeycomb, and sonic throat; the design cycle; theoretical pressure distributions and shock-free limits; drag divergence and stability analysis; and the LFC suction system. Consideration is given to the LFC airfoil model, the air-flow control system, airfoil-surface instrumentation, liner design and hardware, and test options. Extensive diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

N89-18415*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND TUNNEL PRESSURE STUDY AND EULER CODE VALIDATION OF A MISSILE CONFIGURATION WITH 77 DEG SWEPT DELTA WINGS AT SUPERSONIC SPEEDS M.S. Thesis - George Washington Univ.
PATSY S. FULTON Nov. 1988 123 p
(NASA-TM-101531; NAS 1.15:101531) Avail: NTIS HC A06/MF A01 CSCL 01A

A wind-tunnel pressure study was conducted on an axisymmetric missile configuration in the Unitary Plan Wind Tunnel at NASA Langley Research Center. The Mach numbers ranged from 1.70 to 2.86 and the angles of attack ranged from minus 4 degrees to plus 24 degrees. The computational accuracy for limited conditions of a space-marching Euler code was assessed. NASA

N89-18416*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER HUB FAIRING AND PYLON INTERFERENCE DRAG
D. R. GRAHAM, D. Y. SUNG (Sterling Federal Systems, Inc., Palo Alto, CA.), L. A. YOUNG, A. W. LOUIE, and R. H. STROUB Jan. 1989 191 p
(NASA-TM-101052; A-89004; NAS 1.15:101052) Avail: NTIS HC A09/MF A01 CSCL 01A

A wind tunnel test was conducted to study the aerodynamics of helicopter hub and pylon fairings. The test was conducted in the 7-by 10 Foot Subsonic Wind Tunnel (Number 2) at Ames Research Center using a 1/5-scale XH-59A fuselage model. The primary focus of the test was on the rotor hub fairing and pylon mutual interference drag. Parametric studies of pylon and hub fairing geometry were also conducted. This report presents the major findings of the test as well as tabulated force and moment data, flow visualization photographs, and graphical presentations of the drag data. The test results indicate that substantial drag reduction can be attained through the use of a cambered hub fairing with circular arc upper surface and flat lower surface. Furthermore, a considerable portion of the overall drag reduction is attributed to the reduction in the hub-on-pylon interference drag. It is also observed that the lower surface curvature of the fairing has a strong influence on the hub fairing and on pylon interference drag. However, the drag reduction benefit that was obtained by using the cambered hub fairing with a flat lower surface was adversely affected by the clearance between the hub fairing and the pylon. Author

N89-18418*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PREDICTED PITCHING MOMENT CHARACTERISTICS OF X-29A AIRCRAFT
GERALD D. BUDD Mar. 1987 67 p
(NASA-TM-88284; H-1398; NAS 1.15:88284) Avail: NTIS HC A04/MF A01 CSCL 01A

The predicted pitching moment characteristics of the X-29A aircraft are presented for angles of attack from 0 to 20 deg. and Mach numbers of 0.2, 0.6, 0.9, 1.2, and 1.5 for altitudes of sea level, 4572 m (15,000 ft), 9144 m (30,000 ft), and 12,192 m (40,000 ft). These data are for both rigid and flexible aircraft and for the full range of control-surface positions. The characteristics were extracted from a nonlinear, symmetric, flexibilized wind tunnel data base. Author

N89-18419# Naval Postgraduate School, Monterey, CA.
THE EFFECTS OF FREESTREAM TURBULENCE ON AIRFOIL BOUNDARY LAYER BEHAVIOR AT LOW REYNOLDS NUMBERS M.S. Thesis
DAVID W. KINDELSPIRE Sep. 1988 117 p
(AD-A201665) Avail: NTIS HC A06/MF A01 CSCL 20D

An experimental study was conducted to determine the effects of freestream turbulence on airfoil boundary layer behavior. Freestream turbulence intensity levels up to approximately 4% and length scales up to approximately two inches were generated using turbulence-generating grids. Data were collected using a single-wire hot-wire probe in conjunction with a three-dimensional traversing system. Increased levels of freestream turbulence were found to cause correspondingly earlier transition to a turbulent boundary layer. Boundary layer growth was found to be unaffected by freestream turbulence levels up to 4% at length scales an order of magnitude greater than the boundary layer thickness. For length scales on the order of boundary layer thickness, a 12% increase in the turbulent boundary layer thickness was found with an increase in turbulence intensity from 0.23% to 0.5%. GRA

N89-18420# Naval Postgraduate School, Monterey, CA.
A COMPUTER CODE (USPOTF2) FOR UNSTEADY INCOMPRESSIBLE FLOW PAST TWO AIRFOILS M.S. Thesis
CHUNK-KIANG PANG Sep. 1988 169 p
(AD-A201671) Avail: NTIS HC A08/MF A01 CSCL 20D

A numerical code, USPOTF2, has been formulated to solve the potential flow for two airfoils executing unsteady motions is an inviscid incompressible flow medium. This code is an extension of an existing code U2DIIF, which does the same calculations for the single airfoil case. The technique uses the well known Panel Methods for steady flow and extends it to unsteady flow by introducing a wake model which creates a non-linear problem due to the continuous shedding of vortices into the trailing wake. The presence of the second airfoil introduces a set of non-linear coupled equations for the Kutta condition. Numerous case-runs are presented to illustrate the capability of the code. The case of the step change in angle of attack is compared with Giesing's work. All other case-runs are illustrated together with the results for the single airfoil case. GRA

N89-18614# Royal Aircraft Establishment, Bedford (England).
WIND TUNNEL EXPERIMENTS ON AEROFOIL MODELS FOR THE ASSESSMENT OF COMPUTATIONAL FLOW METHODS
P. R. ASHILL, D. J. WEEKS, and J. L. FULKER *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 14 p Dec. 1988
Avail: NTIS HC A25/MF A01

Wind tunnel experiments on two airfoil models (unswept and a 25 deg sweep) at high subsonic speeds and for Reynolds numbers up to about 20 x 1,000,000 are described. Both models had detachable trailing edges for studying flows with differing rear pressure distributions and used a method for fixing transition, which gave precise control of the disturbance to the boundary layer. Following a discussion of the measurement and correction procedures, comparisons are presented between the data and CFD methods: these comparisons reveal the importance for the accurate prediction of the flow over advanced airfoils of including effects in the modeling of the shear layers which become significant as separation is approached. Author

N89-18615*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PARAMETRIC STUDY OF GRID SIZE, TIME STEP AND TURBULENCE MODELING ON NAVIER-STOKES COMPUTATIONS OVER AIRFOILS

CHRISTOPHER L. RUMSEY and W. KYLE ANDERSON *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 19 p Dec. 1988

Avail: NTIS HC A25/MF A01 CSCL 01A

An upwind-biased implicit approximate factorization algorithm is applied to several steady and unsteady turbulent flows. The thin layer form of the compressible Navier-Stokes equation is used. Both the flux vector splitting and flux difference splitting methods are used to determine fluxes, and the results are compared. Flux difference splitting predicts results more accurately than flux vector splitting on a given mesh size, but, in its present implementation, is more severely limited by the maximum CFL number for unsteady time accurate flows. Physical aspects of the computations are also examined. An equilibrium turbulent boundary layer model computes generally better steady and unsteady results than a nonequilibrium model when there is little to no boundary layer separation. Conversely, when a significant region of separation exists, the nonequilibrium model performs in better agreement with experiment. Author

N89-18623# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).

THE DFVLR-F5 WING EXPERIMENT: TOWARDS THE VALIDATION OF THE NUMERICAL SIMULATION OF TRANSONIC VISCOUS WING FLOWS

W. KORDULLA, D. SCHWAMBORN, and H. SOBIECZKY *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 18 p Dec. 1988

Avail: NTIS HC A25/MF A01

A major step towards the rigorous validation of Navier-Stokes codes for the simulation of the transonic flow past transport-type wings is described. The basis for this is the DFVLR-F5 wing experiment which was designed to allow the analytical formulation of a boundary value problem. This requires the determination of flow conditions on the entire surface of the prescribed control volume. The experiment led to the organization of a workshop, selected results of which are presented. These show considerable scatter, the sources of which can not be defined very well because there are too many possible ones, and the salient ingredients are too diverse. Some of the difficulties are illustrated by results of additional computations. Both, experimentalists as well as computational aerodynamicists, have to do more work to achieve a successful validation. Author

N89-18628# Aircraft Research Association Ltd., Bedford (England). GARTEUR Action Group.

ACCURACY STUDY OF TRANSONIC FLOW COMPUTATIONS FOR THREE DIMENSIONAL WINGS

M. P. CARR *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 17 p Dec. 1988

Avail: NTIS HC A25/MF A01

GARTEUR Action Group AD(AG05) has undertaken an investigation of ten flow field methods. Calculations of inviscid flow over the DFVLR F4 wing for two conditions were analyzed. The main results and conclusions are presented. Author

N89-18629# Fokker B.V., Schipol-Oost (Netherlands). Aerodynamics and Aeroelasticity Dept.

CFD APPLICATIONS IN DESIGN AND ANALYSIS OF THE FOKKER 50 AND FOKKER 100

N. VOOGT, W. J. A. MOL, J. STOUT, and D. F. VOLKERS *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 11 p Dec. 1988

Avail: NTIS HC A25/MF A01

Aerodynamic computational codes were used and validated extensively during the aerodynamic development phases of the Fokker 50 and 100 aircraft projects. Validations were made against wind tunnel tests as well as flight measurements. A description is given of the methods on which the codes are based and applications are discussed in areas of intake aerodynamics, low speed high lift flow and transonic flow. Author

N89-18642# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).

NUMERICAL AND EXPERIMENTAL INVESTIGATION OF ENGINE INLET FLOW WITH THE DORNIER EM2 SUPERSONIC INLET MODEL

H. BUERS, S. LEICHER, and P. A. MACKRODT (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 16 p Dec. 1988 Sponsored in part by the Ministry of Defense, Fed. Republic of Germany

Avail: NTIS HC A25/MF A01

Numerical and experimental investigations were conducted with the Dornier EM2 supersonic, fixed geometry, side mounted inlet to improve the performance in the supersonic flight regime. A ramp bleed system is described and some representative results from wind tunnel tests are presented to confirm the procedure. The theoretical investigations were executed with a block structured Euler program, which allowed a more accurate modeling of the realistic aircraft geometry. To simulate boundary layer effects at the ramp of the inlet, an outflow velocity perpendicular to the ramp was introduced. The calculated and the experimental data were in good agreement. Author

N89-18649# Aeritalia S.p.A., Pomigliano D'Arco (Italy). Transport Aircraft Group.

VALIDATION OF A MULTI-BLOCK EULER FLOW SOLVER WITH PROPELLER-SLIPSTREAM FLOWS

A. AMENDOLA, R. TOGNACCINI, J. W. BOERSTOEL, and A. KASSIES (National Aerospace Lab., Amsterdam, Netherlands) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 15 p Dec. 1988

Avail: NTIS HC A11/MF A01

A new computer-program system for the numerical simulation of subsonic and transonic flows around complex aircraft configurations is described. This system computes Euler flows on multi-blocked grids. The system consists of four major parts: a block decomposer for the subdivision of flow domains into blocks, a grid generator for blocked flow domains, a flow solver for blocked grids, and a flow visualizer for flows on blocked grids. These parts are interfaced by files with simple formats. Special attention was given to provide this package of software products with: excellent portability (the system was tested on various front-end and supercomputers), modularity (with respect to physical and numerical subtasks, and with respect of subdividing total simulation task in loosely coupled subtasks). The system has good growth potential towards a Navier-Stokes simulation environment. The system is being validated with various test cases. Results of one of these test cases (the wing/nacelle/propeller configuration tested in a NASA Langley wind-tunnel, NASA CR 172605) show that the system performs reasonably from the point of view of both accuracy and operational manageability. Author

N89-18650# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.

INVESTIGATION OF THE SURFACE FLOW OF CONICAL BODIES AT HIGH SUBSONIC AND SUPERSONIC SPEEDS

W. J. BANNINK, E. M. HOUTMAN, and S. P. OTTOCHIAN *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 14 p Dec. 1988

Avail: NTIS HC A11/MF A01

Turbulent boundary layer calculations have been performed of the flow on the leeward side of two conical bodies at moderate to high angles of attack. A sharp-edged planar 65 deg sweep delta wing at high subsonic speeds up to M (infinity) equals 0.85

and angles of attack up to 15 deg and a 7.5 deg semi-apex angle circular cone at M (infinity) equals 2.95 at 14 deg angle of attack are used. The boundary layer method, based on a finite difference predictor-corrector algorithm, assumes a conical external flow and applies a local (Blasius) similarity concept in radial direction from the apex. The solution marches in cross-direction from the reattachment line toward produced correct results with respect to the location of separation and the surface flow inclination, experimental pressure distributions are used to generate the inviscid solutions at the edge of the boundary layer. The predicted surface flow on both bodies are in close agreement with the experimental results. In particular the location of the separation lines were very close to those observed in oil flow patterns. That the approximate flow model (conical) produces such good results in the case of the delta wing is due to the relatively large spanwise pressure gradients compared to the chordwise gradients. Author

N89-18657*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DETAILED FLOWFIELD MEASUREMENTS OVER A 75 DEG SWEPT DELTA WING FOR CODE VALIDATION
SCOTT O. KJELGAARD and WILLIAM L. SELLERS, III *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 14 p Dec. 1988
Avail: NTIS HC A11/MF A01 CSCL 01A

Selected results from an experimental investigation documenting the flowfield over 75 deg swept delta wing at an angle-of-attack of 20.5 deg are presented. Results obtained in the investigation include surface flow visualization, off-body flow visualization, and detailed flowfield surveys for various Reynolds numbers. Flowfield surveys at Reynolds numbers of 0.5, 1.0 and 1.5 million were conducted with both a pitot pressure probe and a 5-hole pressure probe; and 3-component laser Doppler velocimeter surveys were conducted at a Reynolds number of 1.0 million. The pitot pressure surveys were obtained at 5 longitudinal stations, the 5-hole probe surveys were obtained at 3 longitudinal stations and the laser Doppler velocimeter surveys were obtained at one station. The accuracy of each instrumentation system is discussed, as well as, discrepancies in the calculation of vorticity using various algorithms. Author

N89-18658*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTS AND CODE VALIDATION FOR JUNCTURE FLOWS
L. R. KUBENDRAN, C.-H. SUNG, and C.-I. YANG (Naval Ship Research and Development Center, Bethesda, MD.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 11 p Dec. 1988
Avail: NTIS HC A11/MF A01 CSCL 01A

The turbulent flow around a juncture formed by an unswept wing and a flat plate has been experimentally studied, and the effectiveness of modifications near the wing leading edge in controlling the juncture flow field has been evaluated. The results are compared with numerical solutions of the incompressible Reynolds-averaged Navier-Stokes equations. The Baldwin-Lomax turbulence model is used in the computations. The numerical code is very time efficient, and it predicts the flow behavior well, including the detection of leading-edge vortex formation. It tends to over-predict the boundary layer thickness and the location of the vortex. Both the experiment and computations indicate that the leading edge flow separation is eliminated by the use of a leading-edge fillet designed in this study, resulting in drag reduction. Author

N89-18660# Aeronautical Research Inst. of Sweden, Bromma.
LARGE-SCALE VISCOUS SIMULATION OF LAMINAR VORTEX FLOW OVER A DELTA WING
BERNHARD MUELLER and ARTHUR RIZZI (Aeronautical Research Inst. of Sweden, Stockholm.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 16 p Dec. 1988
Avail: NTIS HC A11/MF A01

A numerical method has been developed to solve the Navier-Stokes equations for laminar compressible flow around delta wings. A large-scale solution on a mesh of 129x49x65 points for transonic flow M (infinity) equals 0.85 alpha equals 10 deg. and Re (infinity), sub C sub R equals 2.38x10 to the 6th around a 65 deg. swept delta wing with round leading edge is presented and discussed. The results reveal the presence of primary, secondary, and even tertiary vortices. Comparison with experiment shows that the interaction between the primary and secondary vortices is obtained correctly and that these results are a more realistic simulation than the one given by the Euler equations. Author

N89-19231*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE NASA LANGLEY LAMINAR-FLOW-CONTROL EXPERIMENT ON A SWEPT, SUPERCRITICAL AIRFOIL - DRAG EQUATIONS
CUYLER W. BROOKS, JR., CHARLES D. HARRIS, and WILLIAM D. HARVEY Mar. 1989 42 p
(NASA-TM-4096; L-16322; NAS 1.15:4096) Avail: NTIS HC A03/MF A01 CSCL 01A

The Langley Research Center has designed a swept, supercritical airfoil incorporating Laminar Flow Control for testing at transonic speeds. Analytical expressions have been developed and an evaluation made of the experimental section drag, composed of suction drag and wake drag, using theoretical design information and experimental data. The analysis shows that, although the sweep-induced boundary-layer crossflow influence on the wake drag is too large to be ignored and there is not a practical method for evaluating these crossflow effects on the experimental wake data, the conventional unswept 2-D wake-drag computation used in the reduction of the experimental data is at worst 10 percent too high. Author

N89-19232*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DRAG MEASUREMENTS ON A LAMINAR-FLOW BODY OF REVOLUTION IN THE 13-INCH MAGNETIC SUSPENSION AND BALANCE SYSTEM
DAVID A. DRESS 1989 37 p
(NASA-TP-2895; L-16483; NAS 1.60:2895) Avail: NTIS HC A03/MF A01 CSCL 01A

Low speed wind tunnel drag force measurements were taken on a laminar flow body of revolution free of support interference. This body was tested at zero incidence in the NASA Langley 13 in. Magnetic Suspension and Balance System (MSBS). The primary objective of these tests was to substantiate the drag force measuring capabilities of the 13 in. MSBS. The drag force calibrations and wind-on repeatability data provide a means of assessing these capabilities. Additional investigations include: (1) the effects of fixing transition; (2) the effects of fins installed in the tail; and (3) surface flow visualization using both liquid crystals and oil flow. Also two simple drag prediction codes were used to assess their usefulness in estimating overall body drag. Author

N89-19234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSONIC UNSTEADY AERODYNAMICS AND AEROELASTICITY 1987, PART 1
SAMUEL R. BLAND, comp. Washington, DC Feb. 1989 261 p Symposium held in Hampton, VA, 20-22 May 1987
(NASA-CP-3022-PT-1; L-16532-PT-1; NAS 1.55:3022-PT-1)
Avail: NTIS HC A12/MF A01 CSCL 01A

Computational fluid dynamics methods have been widely accepted for transonic aeroelastic analysis. Previously, calculations with the TSD methods were used for 2-D airfoils, but now the TSD methods are applied to the aeroelastic analysis of the complete aircraft. The Symposium papers are grouped into five subject areas, two of which are covered in this part: (1) Transonic Small Disturbance (TSD) theory for complete aircraft configurations; and (2) Full potential and Euler equation methods.

N89-19246*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AGARD STANDARD AEROELASTIC CONFIGURATIONS FOR DYNAMIC RESPONSE
E. CARSON YATES, JR. *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 1 p 243-259 Feb. 1989
Avail: NTIS HC A12/MF A01 CSCL 01A

Since emphasis is on the transonic speed range, special importance is placed on configurations for which available data are sufficient to define accurately a transonic flutter boundary. Only configurations with clean, smooth surfaces are considered suitable. Segmented models or models with surface-slope discontinuities are inappropriate. Excluded also, in general, are configurations and data sets that involve behavior that is uncertain or not well understood, uncertain model properties, or know sensitivities to small variations in model properties. In order to assess the suitability of configurations already tested and the associated data for designation as standard, a survey of AGARD member countries was conducted to seek candidates for the prospective set. The results of that survey are given and summarized along with the initial selection of a standard configuration. Author

N89-19247*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSONIC UNSTEADY AERODYNAMICS AND AEROELASTICITY 1987, PART 2
SAMUEL R. BLAND, comp. Washington, DC Feb. 1989 379 p Symposium held in Hampton, VA, 20-22 May 1987
(NASA-CP-3022-PT-2; L-16532-PT-2; NAS 1.55:3022-PT-2)
Avail: NTIS HC A17/MF A01 CSCL 01A

This two part document contains copies of the text and figures for the papers presented at the symposium held at NASA Langley on 20 to 22 May, 1987. The papers are grouped in five subject areas. The areas covered by this part includes the following: Methods for vortex and viscous flows; Aeroelastic applications, and Experimental results and cascade flows.

N89-19248*# Old Dominion Univ., Norfolk, VA.
SOLUTION OF STEADY AND UNSTEADY TRANSONIC-VORTEX FLOWS USING EULER AND FULL-POTENTIAL EQUATIONS
OSAMA A. KANDIL, ANDREW H. CHUANG, and HONG HU *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 261-311 Feb. 1989
(Contract NAG1-648)
Avail: NTIS HC A17/MF A01 CSCL 01A

Two methods are presented for inviscid transonic flows: unsteady Euler equations in a rotating frame of reference for transonic-vortex flows and integral solution of full-potential equation with and without embedded Euler domains for transonic airfoil flows. The computational results covered: steady and unsteady conical vortex flows; 3-D steady transonic vortex flow; and transonic airfoil flows. The results are in good agreement with other computational results and experimental data. The rotating frame of reference solution is potentially efficient as compared with the space fixed reference formulation with dynamic gridding. The integral equation solution with embedded Euler domain is computationally efficient and as accurate as the Euler equations. Author

N89-19249*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VISCOUS FLOW CALCULATIONS FOR THE AGARD STANDARD CONFIGURATION AIRFOILS WITH EXPERIMENTAL COMPARISONS
JAMES T. HOWLETT *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 313-330 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

Recent experience in calculating unsteady transonic flow by means of viscous-inviscid interactions with the XTRAN2L computer code is examined. The boundary layer method for attached flows is based upon the work of Rizzetta. The nonisentropic corrections of Fuglsang and Williams are also incorporated along with the viscous interaction for some cases and initial results are presented. For unsteady flows, the inverse boundary layer equations developed by Vatsa and Carter are used in a quasi-steady manner and preliminary results are presented. Author

N89-19251*# Georgia Inst. of Tech., Atlanta.
NUMERICAL SOLUTION OF UNSTEADY ROTATIONAL FLOW PAST FIXED AND ROTARY WING CONFIGURATIONS
N. L. SANKAR, B. E. WAKE, S. Y. RUO, and J. B. MALONE (Lockheed-Georgia Co., Atlanta.) *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 351-374 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

The application of unsteady 3-D Euler and Navier-Stokes equations to transonic flow past rotor blades, and wing-alone configurations is described. A promising approach for the numerical solution of these equations is examined. Additional work is needed for improving the efficiency of the present procedure. It is hoped that the techniques presented will find use in fixed and rotary wing aircraft analysis. Author

N89-19252*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY NAVIER-STOKES COMPUTATIONS OVER AIRFOILS USING BOTH FIXED AND DYNAMIC MESHES
CHRISTOPHER L. RUMSEY and W. KYLE ANDERSON *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 375-394 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

A finite volume implicit approximate factorization method which solves the thin layer Navier-Stokes equations was used to predict unsteady turbulent flow airfoil behavior. At a constant angle of attack of 16 deg, the NACA 0012 airfoil exhibits an unsteady periodic flow field with the lift coefficient oscillating between 0.89 and 1.60. The Strouhal number is 0.028. Results are similar at 18 deg, with a Strouhal number of 0.033. A leading edge vortex is shed periodically near maximum lift. Dynamic mesh solutions for unstalled airfoil flows show general agreement with experimental pressure coefficients. However, moment coefficients and the maximum lift value are underpredicted. The deep stall case shows some agreement with experiment for increasing angle of attack, but is only qualitatively comparable past stall and for decreasing angle of attack. Author

N89-19253*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE OBLIQUE-WING RESEARCH AIRCRAFT: A TEST BED FOR UNSTEADY AERODYNAMIC AND AEROELASTIC RESEARCH
GLENN B. GILYARD *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 395-414 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

The advantages of oblique wings have been the subject of numerous theoretical studies, wind tunnel tests, low speed flight models, and finally a low speed manned demonstrator, the AD-1. The specific objectives of the OWRA program are: (1) to establish the necessary technology base required to translate theoretical and experimental results into practical mission oriented designs; (2) to design, fabricate and flight test an oblique wing aircraft throughout a realistic flight envelope, and (3) to develop and validate design and analysis tools for asymmetric aircraft configurations. The preliminary design phase of the project is complete and has resulted in a wing configuration for which construction is ready to be initiated. Author

N89-19254*# Purdue Univ., West Lafayette, IN.
STATIC AEROELASTICITY OF A COMPOSITE OBLIQUE WING IN TRANSONIC FLOWS
JONATHAN D. BOHLMANN *In* NASA, Langley Research Center,

Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 415-425 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

One aircraft configuration that shows great promise in achieving high performance is that of an asymmetrically swept wing. When compared to conventional swept wings, these advantages include higher lift to drag ratios and reduced takeoff and landing speeds, which translate into greater performance in terms of fuel comsumption, loiter time, and range. However, the oblique wing has a number of disadvantages because of its asymmetric configuration. The question is how to best achieve maximum stability and roll equilibrium without compromising performance. Using aeroelastic tailoring to enhance aeroelastic stability and control has been demonstrated in several analyses, especially for the forward swept wing. The advantages and disadvantages for the oblique wing configuration are discussed. Author

N89-19255*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INVESTIGATION AND SUPPRESSION OF HIGH DYNAMIC RESPONSE ENCOUNTERED ON AN ELASTIC SUPERCRITICAL WING
DAVID A. SEIDEL, WILLIAM M. ADAMS, JR., CLINTON V. ECKSTROM, and MAYNARD C. SANDFORD *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 427-448 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

The DAST Aeroelastic Research Wing had been previously in the NASA Langley TDT and an unusual instability boundary was predicted based upon supercritical response data. Contrary to the predictions, no instability was found during the present test. Instead a region of high dynamic wing response was observed which reached a maximum value between Mach numbers 0.92 and 0.93. The amplitude of the dynamic response increased directly with dynamic pressure. The reponse appears to be related to chordwise shock movement in conjunction with flow separation and reattachment on the upper and lower wing surfaces. The onset of flow separation coincided with the occurrence of strong shocks on a surface. A controller was designed to suppress the wing response. The control law attenuated the response as compared with the uncontrolled case and added a small but significant amount of damping for the lower density condition. Author

N89-19257*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INITIAL APPLICATION OF CAP-TSD TO WING FLUTTER
HERBERT J. CUNNINGHAM, ROBERT M. BENNETT, and JOHN T. BATINA *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 463-475 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

The initial application of the CAP-TSD computer program for wing flutter analysis is presented. Computational Aeroelasticity Program - Transonic Small Disturbance (CAP-TSD) is based on an approximate factorization (AF) algorithm that is stable and efficient on supercomputers with vector arithmetic. CAP-TSD was used to calculate steady and unsteady pressures on wings and configurations at subsonic, transonic, and supersonic Mach numbers. However, the CAP-TSD code has been developed primarily for aeroelastic analysis. The initial efforts for validation of the aeroelastic analysis capability is presented. The initial applications include two series of symmetric, planar wing planforms. Well defined modal properties are available for these wings. In addition, transonic flutter boundaries are available for evaluation of the transonic capabilities of CAP-TSD. Author

N89-19260*# United Technologies Research Center, East Hartford, CT.
AIRFOIL STALL PENETRATION AT CONSTANT PITCH RATE AND HIGH REYNOLDS NUMBER
PETER F. LORBER and FRANKLIN O. CARTA *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 519-542 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

The model wing consists of a set of fiberglass panels mounted on a steel spar that spans the 8 ft test section of the UTRC Large Subsonic Wind Tunnel. The first use of this system was to measure surface pressures and flow conditions for a series of constant pitch rate ramps and sinusoidal oscillations a Mach number range, a Reynolds number range, and a pitch angle range. It is concluded that an increased pitch rate causes stall events to be delayed, strengthening of the stall vortex, increase in vortex propagation, and increase in unsteady airloads. The Mach number range causes a supersonic zone near the leading edge, stall vortex to be weaker, and a reduction of unsteady airloads. Author

N89-19261*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL TRANSONIC STEADY STATE AND UNSTEADY PRESSURE MEASUREMENTS ON A SUPERCRITICAL WING DURING FLUTTER AND FORCED DISCRETE FREQUENCY OSCILLATIONS
DOUGLAS S. PIETTE (Lockheed-Georgia Co., Atlanta.) and FRANK W. CAZIER, JR. *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 543-570 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

Present flutter analysis methods do not accurately predict the flutter speeds in the transonic flow region for wings with supercritical airfoils. Aerodynamic programs using computational fluid dynamic (CFD) methods are being developed, but these programs need to be verified before they can be used with confidence. A wind tunnel test was performed to obtain all types of data necessary for correlating with CFD programs to validate them for use on high aspect ratio wings. The data include steady state and unsteady aerodynamic measurements on a nominal stiffness wing and a wing four times that stiffness. There is data during forced oscillations and during flutter at several angles of attack, Mach numbers, and tunnel densities. Author

N89-19264*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL AEROELASTICITY CHALLENGES AND RESOURCES
JOHN W. EDWARDS *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 631-637 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 01A

In the past decade, there has been much activity in the development of computational methods for the analysis of unsteady transonic aerodynamics about airfoils and wings. Significant features are illustrated which must be addressed in the treatment of computational transonic unsteady aerodynamics. The flow regimes for an aircraft on a plot of lift coefficient vs. Mach number are indicated. The sequence of events occurring in air combat maneuvers are illustrated. And further features of transonic flutter are illustrated. Also illustrated are several types of aeroelastic response which were encountered and which offer challenges for computational methods. The four cases illustrate problem areas encountered near the boundaries of aircraft envelopes, as operating condition change from high speed, low angle conditions to lower speed, higher angle conditions. Author

N89-19265*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
WIND-TUNNEL RESULTS OF ADVANCED HIGH-SPEED PROPELLERS AT TAKEOFF, CLIMB, AND LANDING MACH NUMBERS
GEORGE L. STEFKO and ROBERT J. JERACKI Nov. 1985 51 p
(NASA-TM-87030; E-2417; NAS 1.15:87030) Avail: NTIS HC A04/MF A01 CSCL 01A

Low-speed wind-tunnel performance tests of two advanced propellers have been completed at the NASA Lewis Research Center as part of the NASA Advanced Turboprop Program. The 62.2 cm (24.5 in.) diameter adjustable-pitch models were tested at Mach numbers typical of takeoff, initial climbout, and landing speeds (i.e., from Mach 0.10 to 0.34) at zero angle of attack in the NASA Lewis 10 by 10 Foot Supersonic Wind Tunnel. Both models had eight blades and a cruise-design-point operating condition of Mach 0.80, and 10.668 km (35,000 ft) I.S.A. altitude, a 243.8 m/s (800 ft/sec) tip speed, and a high power loading of 301 kW/sq m (37.5 shp/sq ft). Each model had its own integrally designed area-ruled spinner, but used the same specially contoured nacelle. These features reduced blade-section Mach numbers and relieved blade-root choking at the cruise condition. No adverse or unusual low-speed operating conditions were found during the test with either the straight blade SR-2 or the 45 deg swept SR-3 propeller. Typical efficiencies of the straight and 45 deg swept propellers were 50.2 and 54.9 percent, respectively, at a takeoff condition of Mach 0.20 and 53.7 and 59.1 percent, respectively, at a climb condition of Mach 0.34. Author

N89-19266*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TWO EXPERIMENTAL SUPERCRITICAL LAMINAR-FLOW-CONTROL SWEPT-WING AIRFOILS
DENNIS O. ALLISON and J. RAY DAGENHART Feb. 1987 24 p
(NASA-TM-89073; NAS 1.15:89073) Avail: NTIS HC A03/MF A01 CSCL 01A

Two supercritical laminar-flow-control airfoils were designed for a large-chord swept-wing experiment in the Langley 8-Foot Transonic Pressure Tunnel where suction was provided through most of the model surface for boundary-layer control. The first airfoil was derived from an existing full-chord laminar airfoil by extending the trailing edge and making changes in the two lower-surface concave regions. The second airfoil differed from the first one in that it was designed for testing without suction in the forward concave region of the lower surface. Differences between the first airfoil and the one from which it was derived as well as between the first and second airfoils are discussed. Airfoil coordinates and predicted pressure distributions for the design normal Mach number of 0.755 and section lift coefficient of 0.55 are given for the three airfoils. Author

N89-19267# National Research Council of Canada, Ottawa (Ontario).
USE OF RIBLETS TO OBTAIN DRAG REDUCTION ON AIRFOILS AT HIGH REYNOLDS NUMBER FLOWS
M. KHALID Aug. 1988 26 p
(AD-A201485; NRC-29459; NAE-AN-53) Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation was carried out to study the drag reduction capabilities of riblets (commercially available) when installed on a supercritical airfoil which was aerodynamically tested in the NAE's High Reynolds Number 2 D Test Facility. The flow conditions in this test ranged from M = 0.15 to M = 0.76, and Re/ft = 1.5 million to Re/ft = 8 million. The airfoil with riblets exhibited less drag than a completely turbulent air foil (without riblets) for Mach Number M less than or = 0.5 and Reynolds Numbers Re/ft less than or = 5 million. It was found that the thinner riblets material (0.0013) gave more attractive drag results than the thicker riblets (0.0030). However, at higher Mach numbers Reynolds number no drag reduction was observed. GRA

N89-19269 Virginia Polytechnic Inst. and State Univ., Blacksburg.
A VORTEX PANEL METHOD FOR POTENTIAL FLOWS WITH APPLICATIONS TO DYNAMICS AND CONTROLS Ph.D. Thesis
CURTIS PAUL MRACEK 1988 313 p
Avail: Univ. Microfilms Order No. DA8825335

A general nonlinear, nonplanar unsteady vortex panel method for potential flow is developed. The surface is modeled as a collection of triangular elements on which the vorticity vector is piecewise linearly varying. The wake emanates from the sides and trailing edges of the thin lifting surfaces and is modeled as a progressively formed collection of vortex filaments. This model provides a continuous pressure distribution on the surface while allowing the wake to roll up as tightly as needed. The wake position is determined as part of the solution and no prior knowledge of the position or strength is assumed. An adaptive grid technique is used to redistribute the circulation of the vortex filaments of the wake as the wake sheet spreads. The aerodynamic model is coupled with dynamic equations of motion. Forced oscillation tests are conducted on flat rectangular and delta wings. Dynamic tests are performed to predict wing rock of a slender delta wing restricted to one degree of freedom in roll. The aerodynamic/dynamic model is coupled with control laws that govern the motion of flaperons so that a prescribed pitch motion is executed and wing rock is suppressed. Dissert. Abstr.

N89-19271 California Inst. of Tech., Pasadena.
TIP VORTICES: SINGLE PHASE AND CAVITATING FLOW PHENOMENA Ph.D. Thesis
SHELDON ISAIAH GREEN 1988 200 p
Avail: Univ. Microfilms Order No. DA8820949

The tip vortex shed by several rectangular planform wings, fitted with three different tips, was studied in a water tunnel. Four techniques were employed to examine the tip vortex: surface flow visualization to reveal the early stages of vortex rollup; double pulsed holography of buoyant, Lagrangian particle tracers for detailed tangential and axial velocity data around the vortex core; holograms were also a source of instantaneous core structure information; tailored air bubble, non-intrusive, measurement of the average and transient vortex core pressure; and direct observation of vortex cavitation. Dissert. Abstr.

N89-19274# Texas Univ., Arlington.
EXPERIMENTAL SIMULATION OF TRANSONIC VORTEX-AIRFOIL INTERACTIONS Final Report, 1 Aug. 1984 - 31 Aug. 1988
DONALD R. WILSON and DONALD D. SEATH 31 Oct. 1988 50 p
(Contract DAAG29-84-K-0131)
(AD-A201934; ARO-21346.4-EG) Avail: NTIS HC A03/MF A01 CSCL 01A

Results from an experimental investigation of helicopter rotor blade-vortex interaction (BVI) phenomena at transonic Mach numbers and at Reynolds numbers representative of actual helicopter flight operations are presented. The study examined both perpendicular (vortex core perpendicular to the blade leading edge) and parallel (vortex core parallel to blade leading edge) interaction geometries. The significant results are: (1) Perpendicular Interaction: The effect of the vortex causes a large reduction in upper surface pressure distribution (lift increase). This lift increase correlates with strength of the vortex and closeness of the vortex encounter. The interaction is most pronounced near the leading edge of the airfoil. A large spanwise deflection of the vortex is observed as it passes over the airfoil. (2) Parallel Interaction: A similar reduction in upper surface pressure distribution is also observed during the transient passage of the parallel vortex over the airfoil. Like the perpendicular interaction, this effect is also most pronounced near the leading edge, which is in contrast to the general results of numerous CFD simulations. For certain combinations of vortex strength and encounter distance, a class-C shock motion (forward propagation of the airfoil shock wave) was observed. GRA

N89-19275# General Dynamics Corp., Fort Worth, TX.
UNSTEADY LOW-SPEED WIND TUNNEL TEST OF A STRAKED DELTA WING, OSCILLATING IN PITCH. PART 2: PLOTS OF STEADY AND ZEROTH AND FIRST HARMONIC UNSTEADY PRESSURE DISTRIBUTIONS Final Report, Jun. 1985 - Aug. 1987
A. M. CUNNINGHAM, JR., R. G. DENBOER, C. S. G. DOGGER, E. G. M. GUERTS, A. J. PERSOON, A. P. RETEL, and R. J. ZWAAN (National Aerospace Lab., Amsterdam, Netherlands) Apr. 1988 309 p
(Contract F33615-85-C-3013)
(AD-A201936; AFWAL-TR-87-3098-PT-2) Avail: NTIS HC A14/MF A01 CSCL 01A

Results of a wind tunnel test of an oscillating straked wing are given. The report provides unsteady airloads and pressure distributions for a range of incidences (-8 to 50 deg.) and amplitudes

(1 to 16 deg.). The wind speed was 80 meters/second, which provided reduced frequencies up to 0.50 based on root chord. The zeroth and first harmonic as well as the continuous time history of the pressure and overall loads were measured. Flow visualization was performed for flow of 30 meters/second using a pulsating laser light sheet. The plots of the pressure distributions included in this part are presented in the order of the run numbers. Tables 4 and 5 in part 1 provide a convenient cross reference of conditions and run numbers. All steady test cases which were covered in table 4 of part 1 are presented in appendix B for runs up to no. 674. All runs presented in this part relate to the test conditions of 80 m/s windspeed and zero sideslip. GRA

N89-19276# Naval Surface Warfare Center, Dahlgren, VA.
DRAG COEFFICIENTS FOR IRREGULAR FRAGMENTS Final Report
FRANK MCCLESKEY Feb. 1988 111 p
(AD-A201943; NSWC-TR-87-89) Avail: NTIS HC A06/MF A01
CSCL 20D

Drag coefficients for irregular fragments were determined for 96 fragments in a vertical wind tunnel at Mach numbers of approximately 0.1. Correlation of drag coefficient with the maximum-to-average presented area ratio is presented. A method for approximating the whole drag curve is also given. Physical characteristics, photos, and wind tunnel test results are given in the appendixes. GRA

N89-19277# Ballistic Research Labs., Aberdeen Proving Ground, MD.
NUMERICAL COMPUTATIONS OF TRANSONIC CRITICAL AERODYNAMIC BEHAVIOR
JUBARAJ SAHU Dec. 1988 38 p
(AD-A202412; BRL-TR-2962) Avail: NTIS HC A03/MF A01
CSCL 20D

The determination of aerodynamic coefficients by shell designers is a critical step in the development of any new projectile design. Of particular interest is the determination of the aerodynamic coefficients at transonic speeds. It is in this speed regime that the critical aerodynamic behavior occurs and a rapid change in the aerodynamic coefficients is observed. Three-dimensional transonic flow field computations over projectiles have been made using an implicit, approximately factored, partially flux-split algorithm. A composite grid scheme has been used to provide the increased grid resolution needed for accurate numerical simulation of three-dimensional transonic flows. Details of the asymmetrically located shockwaves on the projectiles have been determined. Computed surface pressures have been compared with experimental data and are found to be in good agreement. The pitching moment coefficient, determined from the computed flow fields, shows the critical aerodynamic behavior observed in free flights. GRA

N89-19278# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Aeronautics.
TWO-DIMENSIONAL TEST SECTION WITH PREADJUSTED ADAPTIVE WALLS FOR LOW SPEED WIND TUNNEL
F. KHADJAVI Oct. 1987 17 p
(KTH-AERO-REPT-57; TRITA-FPT-051; ISSN-0280-1078) Avail: NTIS HC A03/MF A01

Some relevant methods for reducing or eliminating the wall interference effects in wind tunnels are mentioned. A calculation method was suggested for a preadjusted adaptive wall test section. Some different arrangements for a contraction - transition - test section - transition - diffuser configuraton were discussed. The effects of test section height and length on the model were investigated. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A89-29275#
OVERVIEW OF ICING RESEARCH AT ONERA
DIDIER GUFFOND, JOSEPH CASSAING, ROBERT HENRY, and MARC BOSSY (ONERA, Chatillon-sous-Bagneux, France) (Congres International sur le Givrage Atmospherique des Structures, 4th, Paris, France, Sept. 5-7, 1988) ONERA, TP, no. 1988-123, 1988, 7 p. refs
(ONERA, TP NO. 1988-123)

Research on aircraft icing and deicing is reviewed, including results of computer simulation studies and wind tunnel tests. The simulation computation codes include the calculation of the impingement on a wing or on an aircraft nose and simulations of an electrical deicer and a thermal antiicer. Also, wind tunnel tests on oscillating blade component and down-scale rotors are examined. R.B.

A89-30539
SENSITIVITY OF FATIGUE CRACK GROWTH PREDICTION (USING WHEELER RETARDATION) TO DATA REPRESENTATION
J. M. FINNEY (Defence Science and Technology Organisation, Aeronautical Research Laboratories, Melbourne, Australia) Journal of Testing and Evaluation (ISSN 0090-3973), vol. 17, March 1989, p. 75-81. refs

Using the Wheeler (1972) model for predicting fatigue crack growth as a case study, the likely errors in prediction from selecting literature calibration values are examined. From four methods of representing the same da/dN - Delta K data, errors in crack life prediction up to a factor of about three were obtained. Because calibration values are stress-scale dependent, the influence of interpolations and extrapolations on predicted crack growth life is also examined. Large extrapolations may lead to errors in predicted life, also approaching a factor of three. Author

A89-30650*# Texas A&M Univ., College Station.
ON ICE SHAPE PREDICTION METHODOLOGIES AND COMPARISON WITH EXPERIMENTAL DATA
K. D. KORKAN and R. K. BRITTON (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting, 27th, Reno, NV, Jan. 9-12, 1989. 14 p. refs
(Contract NAG3-626)
(AIAA PAPER 89-0732)

Comparisons are made between the analysis of Wilder (1969), Bragg (1982), and the ice shape predictions of LEWICE given a specific airfoil geometry and set of meteorological conditions. Also, comparisons are made between the actual ice shapes as found in flight tests of the NASA Lewic RC Twin Otter and that predicted by the approximate methods noted earlier and LEWICE. Further, an investigation of two important parameters in the analysis of LEWICE has been made. Time stepping and initial surface roughness has been varied to identify any trends in the results. Guidelines have been identified for the correlation of these two parameters with the results in terms of atmospheric conditions. The range of meteorological conditions chosen, such as droplet diameter, free air temperature, and liquid water content has allowed rime, mixed, and glaze ice shapes at the leading edge of an airfoil to be investigated. Author

A89-30964
APPLICATIONS OF DUAL AIRCRAFT FORMATION FLIGHTS
DONALD H. LENSCHOW (National Center for Atmospheric Research, Boulder, CO) and LEIF KRISTENSEN (Forsogsanlaeg Riso, Roskilde, Denmark) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 5, Dec. 1988, p. 715-726. refs

This paper discusses procedures for analyzing dual aircraft formation flights, using time-lapse photographs of one aircraft from the other, combined with inertial navigation system position measurements, to estimate the displacement vector between the two aircraft. It is shown that accuracies of a few percent of the separation distance can be readily achieved, and a technique is developed for aligning the data sets from the two aircraft to correct for variations in the longitudinal component of the displacement vector. An expression is then derived for the variance of the difference between measurements of the same variable on each aircraft, as a function of averaging time and separation distance. An example of data from a series of formation flights over eastern Colorado is used to demonstrate the techniques for estimating the displacement vector, aligning the data sets, and calculating lateral coherences and phase angles. Author

A89-31650* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A COMPUTER-BASED SAFETY ASSESSMENT FOR FLIGHT EVACUATION - SAFE

ROBERT J. SHIVELY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: Human Factors Society, Annual Meeting, 32nd, Anaheim, CA, Oct. 24-28, 1988, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1988, p. 885-888. refs

The Safety Assessment for Flight Evacuation (SAFE) system has been developed for the computerized evaluation of safety in civil Emergency Medical Service (EMS) operations. The speed of the microprocessor used to analyze data allows many individual factors to be considered, as well as the interactions among those factors. SAFE's data base is structured as if-then conditional statements. SAFE also allows the most important of the factors to be given greater weight in the final score. The questionnaire filled by EMS crews encompassed mission-, crew-, organization-, environment-, and aircraft-related factors; each of these was subdivided into as many as eight variables affecting the EMS-mission risk of that factor. O.C.

A89-31821#

ELECTROMAGNETIC DISTURBANCES ASSOCIATED WITH LIGHTNING STRIKES ON AIRCRAFT [PERTURBATIONS ELECTROMAGNETIQUES ASSOCIEES AU FOUDROIEMENT D'UN ARONEF]

JEAN-LOUIS BOULAY (ONERA, Chatillon-sous-Bagneux, France) (Societe des Electriciens, des Electroniciens et des Radio-Electriciens, Journees d'Etude sur les Recents Progres dans les Recherches sur la Foudre, Gif-sur-Yvette, France, Nov. 23, 24, 1988) ONERA, TP, no. 1988-163, 1988, 10 p. In French. refs

(ONERA, TP NO. 1988-163)

The simulation of lightning using ground-based lightning measurements is discussed, with application to aeronautical equipment qualification. The instrumentation of the Transall aircraft is described, and electromagnetic field measurements obtained aboard the aircraft are presented. Special attention is given to the the aircraft behavior during the first attachment phase. R.R.

A89-32339

DETECTABILITY OF EMERGENCY LIGHTS FOR UNDERWATER ESCAPE

J. R. ALLAN, D. H. BRENNAN, and G. RICHARDSON (RAF, Institute of Aviation Medicine, Farnborough, England) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 60, March 1989, p. 199-204. refs

The time to detect each of three underwater lights by six subjects was measured in clear and turbid (attenuation coefficient = 4.2/m water), at distances of 1.54 m and 3.1 m, from two viewing angles, straight ahead (0 deg) or 65 deg to one side, and under three levels of ambient illumination. The lights were viewed either through a window, to simulate the use of a face mask, or with the subjects immersed. All lights were detected rapidly (under 1 sec) when viewed through the window in clear water. In turbid conditions, none of the lights was seen at 3.1 m by any subject. At a 1.54 m viewing distance, reliable detection by immersed subjects was found only in the clear water under the two darker ambient illuminations. In turbid water, detection was unreliable. It is concluded that the design of underwater escape lighting should not rely on visibility over distances greater than 1.5 m, and that an illuminated guide-bar might provide valuable assistance in directing escape from aircraft. Author

N89-18421# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.

ENERGY ABSORPTION OF AIRCRAFT STRUCTURES AS AN ASPECT OF CRASHWORTHINESS

Dec. 1988 327 p In ENGLISH and FRENCH Meeting held in Luxembourg, 1-6 May 1988

(AGARD-CP-443; ISBN-92-835-0485-2) Avail: NTIS HC A15/MF A01

Considerable effort was hitherto devoted to crash avoidance, but relatively little to crash survivability. In certain regimes the risk of accident remains, e.g., the low-altitude low-speed regime. There is a strong incentive to increase the prospects for occupant survival through improvements in airframe design. Information about structural behavior and characteristics under these conditions is very sparse and an exchange of information between the NATO nations is long overdue. At its sixty-sixth meeting, the Structures and Materials Panel held a conference of specialists, the aim of which was to stimulate an exchange of experience and development results. A further aim was to act as a focus for the discussion of those design philosophies which may be needed to provide the balance between survivability and functions. The document contains the papers presented.

N89-18422# Ingenieur a la Direction des Constructions Aeronautiques, Paris (France).

REGULATORY ASPECT OF CRASHWORTHINESS [ASPECT REGLEMENT DU CRASHWORTHINESS]

P. J. RABOURDIN *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 14 p Dec. 1988 In FRENCH

Avail: NTIS HC A15/MF A01

Aircraft crashworthiness is examined from the perspective of safety and regulation. The past and anticipated evolution of crash-related regulations is described. Two main areas of regulatory concern for the future are identified and discussed: acceleration attenuation (including modification of safety standards related passenger seating) and passenger evacuation. Author

N89-18423# Army Aviation Systems Command, Fort Eustis, VA. Safety and Survivability Technical Area.

EVOLVING CRASHWORTHINESS DESIGN CRITERIA

C. HUDSON CARPER and LEROY T. BURROWS *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 8 p Dec. 1988

Avail: NTIS HC A15/MF A01

Although significant strides were made in recent years toward improving aviation safety, mishaps involving all classes of helicopters presently are and will continue to be a major, expensive U.S. Army problem in terms of casualties, material loss, and reduction in mission effectiveness. Modern day training and tactical employment requirments for the U.S. Army helicopter dictate that a large percentage of operations occur in the low-speed, low-altitude flight regime, which contributes to the problem by reducing critical margins of safety normally associated with higher airspeed and higher altitude operations with accompanying greater time for response in case of an emergency. This increased probability of accident occurrence, coupled with the lack of in-flight egress capability, makes design for crashworthiness essential for Army helicopters. The evolution of crash survival design for rotary-wing aircraft and its application to current and new generation Army helicopters are discussed. Emphasis is given to the need for a total systems' approach in design for crashworthiness and the necessity for considering crashworthiness early in the design phase of an aviation weapons development effort. The actual application of crashworthiness to Army helicopters is presented with statistics that show dramatic reductions in fatalities and injuries with implementation of a crashworthy fuel system. The cost effective aspects of designing helicopters to be more crash survivable are also discussed. Author

N89-18424# Cranfield Inst. of Tech., Bedford (England). Impact Centre.

CRASHWORTHINESS DESIGN METHODS APPLICABLE AT CONCEPT STAGE

M. M. SADEGHI *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 21 p Dec. 1988

Avail: NTIS HC A15/MF A01

For the effective incorporation of the secondary safety into structures developed for aircraft and moving vehicles, it is essential to tackle crashworthiness in the early stage of the development. For a set of defined loading conditions (crash or crush) to which the structure must comply, it is of great benefit to specify necessary guidelines for defining collapse zones, as well as structural properties concerning nonlinear behavior of constituent components and joints of the overall structure. A hybrid approach is described which predicts the crash behavior of an impacting structure which is tailored to velocities which do not exceed 30 to 40 miles/h. The method involves using component and joint test data (as data base) in conjunction with coarse finite element idealization to determine the collapse mechanism sequence of the collapse and collapse speed of an impacting structure. Author

N89-18425# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).

CRASHWORTHINESS ACTIVITITES ON MBB HELICOPTERS

F. OCH *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 22 p Dec. 1988

Avail: NTIS HC A15/MF A01

Crashworthiness activities at MBB date back to the late sixties, when during BO 105 development crash protection systems such as seats, fuel systems, and landing gears were developed which are integrated in the military versions of the BO 105 for the German Army. In February 1974 a BO 105 was crash tested to show compliance with the Crash Survival Design Guide (TR 71-22) under an impact condition of 15 m/s longitudinal and 8 m/s vertical velocity. Since the mid-seventies theoretical studies were conducted with the aide of the computer program KRASH and nonlinear finite element codes, supported by the German Ministry of Defence, and partly verified by component tests. The experience with the crash behavior of the BO 105 was successfully used for the development of the BK 117 which was shown by a full-scale crash test, conducted in 1985 by Kawasaki, MMB's partner in the BK 117 development. Effective design tools, both in house and at subcontractors and experience with helicopters in service are used at MBB to contribute significantly to fulfill the crash requirements in European helicopter programs and in joint development with foreign partners. Although crash protection techniques and crashworthiness prediction methods are already fairly well established, there still remains a lot of tasks, mainly when using advanced materials and in improving the analytical methods from an economic point of view. Author

N89-18426# Politecnico di Milano (Italy). Dept. of Aerospace Engineering.

THE DESIGN OF HELICOPTER CRASHWORTHINESS

V. GIAVOTTO, C. CAPRILE, and G. SALA *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 9 p Dec. 1988

Avail: NTIS HC A15/MF A01

The extensive use of composite materials in helicopter structures has prompted research activities in crashworthiness in the last decade. A rational design of crashworthy structures requires a great deal of data and experience to be collected and organized; in particular the most efficient mechanisms of energy absorption must be understood and carefully investigated and consequently the best structural concepts and detail design can be identified. With this aim and in cooperation with Agusta Helicopters a research program was undertaken, covering many of the basic aspects of crashworthy design, i.e., dynamic experimentation on subcomponents and subassemblies, hybrid and true finite element modeling, design, and verification procedures. The paper presents some preliminary results, together with the outline of the whole program. Author

N89-18427# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).

DEVELOPMENTS AND PERSPECTIVES AT AMD-BA IN THE FIELD OF IMPACT AND CRASH SIZING [DEVELOPPEMENTS ET PERSPECTIVES DANS LE DOMAINE DU DIMENSIONNEMENT AUX IMPACTS ET AU CRASH AUX AMD—BA]

Y. MARTIN-SIEGFRIED *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 13 p Dec. 1988 In FRENCH; ENGLISH summary Original language document was announced in IAA as A89-21407

Avail: NTIS HC A15/MF A01

Impact and soft crash sizing simulations were performed using a finite-element global ground-aircraft model. Results are presented for the hard landing of a Mercure aircraft and the soft crash of a Falcon 900 aircraft. The data will be used as input in the dynamic and nonlinear modeling of hard crash problems for commuter-type aircraft such as the Falcon 10. B.G.

N89-18428# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Safety and Survivability Technical Area.

FULL SCALE HELICOPTER CRASH TESTING

HAROLD HOLLAND and KENT F. SMITH *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 7 p Dec. 1988

Avail: NTIS HC A15/MF A01

Today, analytical math models are becoming more capable of predicting the dynamic behavior of aircraft structures and occupants subjected to crash loads. The engineering community still finds it necessary, however, to periodically perform full-scale crash tests for the purpose of validating math models, exploring crashworthy component design concepts, defining synergistic effects, or a variety of other goals. Aspects of full-scale aircraft crash testing based on almost 30 years experience by the U.S. Army Aviation Applied Technology Directorate (AVSCOM) and its predecessor organizations are addressed. Though each test is unique, certain principles and procedures were found to provide a high degree of assurance of acquiring accurate data. Author

N89-18429# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).

CRUSHING BEHAVIOUR OF HELICOPTER SUBFLOOR STRUCTURES

J. FRESE and D. NITSCHKE *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 23 p Dec. 1988

Avail: NTIS HC A15/MF A01

Crash loads must be attenuated in the landing gear, the subfloor structure, and the seat to values tolerable for the human body. In addition the remaining loads must not jeopardize a living space for the occupants. A program was undertaken to investigate, both analytically and experimentally, the crushing behavior of helicopter subfloor structures. Stiffened panels and honeycomb sandwich panels in metal were considered under quasistatic and dynamic conditions. The primary intent of the investigations was to design subfloor structures with high efficiency for crash impact and to establish the nonlinear characteristics of subfloor structures as input data for the program KRASH. Author

N89-18430# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.). Inst. for Structures and Design.

CRASH INVESTIGATIONS WITH SUB-COMPONENTS OF A COMPOSITE HELICOPTER LOWER AIRPLANE SECTION

CH. KINDERVATER, A. GIETL, and R. MUELLER (Messerschmitt-Boelkow-Blohm G.m.b.H., Munich, Germany, F.R.) *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 18 p Dec. 1988
Avail: NTIS HC A15/MF A01

For the BK 117 helicopter a composite fuselage was designed, manufactured, and will be flight tested at MBB. Within the development program evidence was given to the crashworthy design of the fuselage which was accomplished by a joint activity between MBB and DFLVR Stuttgart. The crash investigations were focused on the lower airframe section under vertical crash loads. The task was performed by design support tests on the specimen level and by subcomponent crush testing. Sandwich panel specimens were statically and dynamically crushed to study various crush initiators at the panel-skin intersections, and to investigate the energy absorption capability. Subcomponent crush tests under quasi-static loading were concentrated on structural node points (intersections of keel beams and bulkheads) and on bulkheads located in the rear of the fuselage. The component's crush characteristics and the energy absorption performance were determined. Various designs with notched corners at the intersections of beams and bulkheads were considered with the aim to reduce the initial peak failure loads. Structural elements supporting the parallel panels of the landing skid frames were used to avoid global buckling and to initiate and stabilize efficient energy absorption crush modes. The generated load-deflection characteristics of the subcomponents are intended to be used as inputs for crash simulation calculations. Author

N89-18431# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.). Inst. for Structures and Design.
CRASHWORTHY DESIGN OF AIRCRAFT SUBFLOOR STRUCTURAL COMPONENTS
CH. KINDERVATER, H. GEORGI, and U. KOERBER *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 24 p Dec. 1988
Avail: NTIS HC A15/MF A01

Subfloor beams and bulkheads in aircraft structures are designed to carry longitudinal and shear loads resulting from fuselage bending and torsion. In crashes, however, the subfloor is highly loaded in compression and shear. Especially the intersections of beams and bulkheads represent stiff vertical hard points, and the resulting high peak failure loads under compression can create life threatening crash pulses to the occupants. For a commuter type aircraft subfloor aluminum as well as composite cruciforms were designed to match the same longitudinal stiffness of the floor beams and the same shear stiffness of the bulkheads. Various designs of the intersections including notched corners, corrugated and tapered edge joints, and less stiff laminate layups were investigated to reduce the initial peak loads, and to trigger efficient energy absorbing crush failure modes. The cruciforms and subelements such as angle stiffeners and angle stiffened plates were statically crush tested in order to gain information about the complex collapse behavior of subfloor construction. Based on the load-deflection curves important energy absorption parameters were determined, and were compared to the aluminum baseline design. For crash simulations with so called hybrid computer codes load deflection curves of structural elements are needed as input data. For the cruciforms and sub-elements, the prediction of load deflection curves are presented and discussed including plastic hinge formation and approximate mean crush load prediction as well as failure load and critical stress evaluations. Author

N89-18432# Centre d'Essais Aeronautique Toulouse (France). Lab. d'Essais de Crash.
METHOD AND MEANS FOR GROUND CRASH TESTING AT THE CENTRE D'ESSAIS AERONAUTIQUE DE TOULOUSE: APPLICATION TO THE SA 341 AND AS 332 HELICOPTERS [METHODE ET MOYENS D'ESSAIS D'ECRASEMENT AU SOL AU CENTRE D'ESSAIS AERONAUTIQUE DE TOULOUSE: APPLICATION AUX HELICOPTERES SA 341 ET AS 332]
RENE GUINOT *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 26 p Dec. 1988
In FRENCH
Avail: NTIS HC A15/MF A01

Test installations and methodologies used for evaluating the general structural response and crashworthiness of helicopters are discussed. In particular, a 20-meter vertical drop tank, a horizontal acceleration stand, a vehicle crash installation, a landing dynamics stand, and a severe crash installation are described. The kinds of results obtained from each test stand are listed. Data acquisition and analysis strategies are also described. Finally, some results obtained for the SA 341 Gazelle and the AS 332 Super Puma are summarized. Author

N89-18433# Institut de Mecanique des Fluides de Lille (France).
NUMERICAL AND EXPERIMENTAL STUDY OF THE CRASH BEHAVIOR OF HELICOPTERS AND AIRCRAFT [ETUDE NUMERIQUE ET EXPERIMENTALE DU COMPORTEMENT AU CRASH DES HELICOPTERES ET DES AVIONS]
F. DUPRIEZ, P. GEOFFROY, J. L. PETITNIOT, and T. VOHY *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 17 p Dec. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

The crash behavior of helicopters and fixed-wing aircraft was studied numerically by the finite element method and experimentally using representative models. Experimental results obtained with a falling autorotating helicopter compared with full-scale testing results. An experimental study of the landing of a light aircraft on soft ground is discussed. Elastoplastic bending results and data on the crushing of metallic structures were applied to the numerical study of a commercial aircraft structure. M.G.

N89-18434# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
STUDY OF THE DYNAMIC BEHAVIOUR OF STIFFENED COMPOSITE FUSELAGE SHELL STRUCTURES
J. S. HANSEN and R. C. TENNYSON *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 12 p Dec. 1988
Avail: NTIS HC A15/MF A01

An overview of the development of a computer model for analyzing the crash response of stiffened composite fuselage structures is presented together with the experimental validation program. Using a finite element formulation based on Reissner/Mindlin plate theories, the numerical model can treat stiffened laminated shell buckling, large deflections, nonlinear material behavior, and element failure. Numerical results are presented for several test cases, although experimental comparisons are not yet available. Details on the design and construction of the first prototype composite fuselage model are also provided together with a description of the crash test facility. Author

N89-18435# Lockheed Aeronautical Systems Co., Burbank, CA.
TRANSPORT AIRPLANE CRASH SIMULATION, VALIDATION AND APPLICATION TO CRASH DESIGN CRITERIA
G. WITTLIN and C. CAIAFA (Federal Aviation Administration, Atlantic City, NJ.) *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 23 p Dec. 1988
Avail: NTIS HC A15/MF A01

A brief description of the evolutionary development of the program KRASH to its most recent release, KRASH85, is presented, and some background is provided to delineate various program features as well as to illustrate the range of aircraft configurations and impact conditions for which the program was validated. The application of program KRASH to analyze the structural crash dynamics behavior of a narrow-body commercial jet transport aircraft used in the FAA/NASA conducted Controlled Impact Demonstration (CID) test is discussed. A description of the modeling along with comparative results between test and analyses is provided. Included in the correlation effort are acceleration time histories, sequence of impact events, fuselage crush distribution, wing and fuselage bending moment distributions, and estimates of moment and shear strength levels. The results of the transport aircraft correlation effort are used in a subsequent parametric study to formulate a crash design velocity envelope. Parametric analyses, section test and full-scale crash test results are utilized and presented in the form of acceleration time histories at the cabin floor. The transport crash design envelope, along with additional data, is used to assess the effect of aircraft size on floor acceleration pulses in a survivable crash environment. The most recent applications of KRASH are discussed. Author

N89-18436# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
CRASHWORTHINESS OF AIRCRAFT STRUCTURES
W. JARZAB and R. SCHWARZ *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 13 p Dec. 1988
Avail: NTIS HC A15/MF A01

Modern analytical models and their numerical realizations have become powerful tools in nonlinear crash analysis. Crash simulation has to consider advanced nonlinear constitutive equations and sophisticated formulations of the contact problem. The refinement of discretization and the treatment of geometrical complex structures requires highly developed hardware like the vector processor. Topics discussed are the material modeling of impact loaded composite structures, the main features of an explicit crash code and the results of two calculations simulating the drop test of a B707-section. Finally the possibilities of a specific interface between a crash code based on the finite element method like ANCS and a program like KRASH85 are outlined in detailed. Author

N89-18437# Engineering System International, Eschborn (Germany, F.R.).
CRASH SIMULATION AND VERIFICATION FOR METALLIC, SANDWICH AND LAMINATE STRUCTURES
D. ULRICH, A. K. PICKETT, E. HAUG, and J. BIANCHINI (Engineering System International, Rungis, France) *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 18 p Dec. 1988
Avail: NTIS HC A15/MF A01

Some of the research for crash simulation of structures using metallic and composite construction recently undertaken at ESI is outlined. Several current areas of interest are reviewed including helicopter stiffened panel construction, automotive structures, and, on a micro level, the compressive failure analysis of Carbon-Epoxy test coupons. In each study a specialized finite element code is used. The dynamic buckling behavior of panels stiffened with Z sections are simulated numerically. The various components are connected using specially developed rivet elements that fail at a prescribed load and are intended to produce a controlled collapse mode. These panels form the lower structure of a helicopter frame which also houses a flexible membrane fuel compartment. The effect of this internal hydrostatic loading is also represented during the crash event. Some preliminary dynamic investigations for failure predictions of honeycomb core panels are also discussed. Verification of these numerical procedures with experimental behavior is an important issue. The automotive industry has well defined experimental test procedures which provide an excellent standard to assess and validate numerical results. The progressive failure analysis of Carbon-Epoxy fiber test coupons loaded in compression and in bending are undertaken using the program PAM-FISS. The material model uses a BI-PHASE concept in which the constituent matrix and fiber materials have independent mechanical and failure criteria. Author

N89-18438# H. W. Structures Ltd., Pitsea (England).
PREDICTING CRASH PERFORMANCE
D. PARSONS and A. BELFIELD *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 13 p Dec. 1988
Avail: NTIS HC A15/MF A01

In the past, aircraft were designed with high structural integrity such that crash situations can be avoided, i.e., aircraft were designed for crash avoidance and not crashworthiness. There is considerable effort now being devoted to the study of aircraft crashworthiness. Clearly, it is only in relatively low speed impacts that design considerations may be effective. In this area, H.W. Structures, LTD and the automotive environment in general have built up a wealth of experience. How this experience may be applied to aircraft structures is discussed. Analytical techniques for prediction of the behavior of the structure and its occupants are examined. Author

N89-19282# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Hauptabteilung Verkehrforschung.
SIMULTANEOUS THREE-DIMENSIONAL MODELING OF COMMERCIAL FLIGHTS WITHIN THE AIRSPACE OF THE FEDERAL REPUBLIC OF GERMANY
HANNS-JUERGEN PETERS Oct. 1987 307 p In GERMAN; ENGLISH summary
(DFVLR-FB-88-31; ISSN-0171-1342; ETN-89-93970) Avail: NTIS HC A14/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Federal Republic of Germany, 91.50 deutsche marks

A model is set up to simulate commercial flights in 4-D mode. Basic data are standard flight tracks of German domestic flights; altitudes included range up to FL 630. For simulation runs, flight times and profiles are derived both from real flights and departure times, and fly-over times of the Berlin gates. Aircraft movements are simulated with respect to airways, departure and arrival routes, air traffic control areas, starts, and landings. Conflicts arise in the case of too short distances to other aircraft. They are solved depending on flight attitude, e.g., en route state by changing the flight level, or by holding procedures if an aircraft cannot be sequenced for final approach. The simulation is carried out for 465 domestic flights per day. Results are given for defined model segments, for number of conflicts, distribution, and type of solution. ESA

N89-19858*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
LIGHT WEIGHT ESCAPE CAPSULE FOR FIGHTER AIRCRAFT
JAMES A. ROBERT *In* NASA. Lyndon B. Johnson Space Center, 2nd Annual Workshop on Space Operations Automation and Robotics (SOAR 1988) p 303-307 Nov. 1988
Avail: NTIS HC A22/MF A01 CSCL 01C

Emergency crew escape capabilities have been less than adequate for fighter aircraft since before WW II. From the over-the-side bailout of those days through the current ejection seat with a rocket catapult, escaping from a disabled aircraft has been risky at best. Current efforts are underway toward developing a high-tech, smart ejection seat that will give fighter pilots more room to live in the sky, but an escape capsule is needed to meet current and future fighter envelopes. Escape capsules have a bad reputation due to past examples of high weight, poor performance and great complexity. However, the advantages available demand that a capsule be developed. This capsule concept will minimize the inherent disavantages and incorporate the benefits while integrating all aspects of crew station design. The resulting design is appropriate for a crew station of the year 2010 and includes improved combat acceleration protection, chemical or biological combat capability, improved aircraft to escape system interaction, and the highest level of escape performance achievable. The capsule is compact, which can allow a reduced aircraft size and weighs only 1200 lb. The escape system weight penalty is only 120 lb higher than that for the next ejection seat and the capsule has a corresponding increase in performance. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A89-30538
AIRCRAFT ANTENNAS
R. A. BURBERRY Aeronautical Journal (ISSN 0001-9240), vol. 93, Feb. 1989, p. 58-65.

An account is given of the state-of-the-art in aircraft antenna siting rules responsible for the increasing range of airborne radio communications, with a view to prospective problems. Current development trends are dominated by the fact that many airborne antennas operating in the 30-1000 MHz range will be monopoles; electrically short antennas tend to be instantaneously narrow-band, and are often far less efficient than a quarter-wave element. Attention is given to the siting criteria for low-directivity antennas, conformal antenna arrays, and multiband and HF antennas. O.C.

A89-31015
A SURVEY ON FADING CHANNEL OVER WEST-JAVA AREA FOR FLIGHT TEST RADIO TELEMETERING PURPOSES
ADI DHARMA SOELAIMAN and RINA PUDJIASTUTI (Indonesian Aircraft Industry, Ltd., Bandung, Indonesia) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 207-222. refs

Topographical data and radio reception patterns received by ground telemetry stations are used to characterize L-band radio wave propagation in West Java. The channels' characterization with respect to polarization-diversity reception is conducted by a statistical analysis of an aircraft-transmitted 1531 MHz signal's strength. Computer-calculated correlograms indicate the existence of a radio corridor at 265 deg relative to the ground-based receiving antenna. Attention is given to predicted multipath gain factors. O.C.

A89-31052
CONTROL DATA CORPORATION MMTS MULTI-VEHICLE METRIC AND TELEMETRY SYSTEM
RICHARD K. ASPNES (Control Data Corp., Systems Integration Div., Englewood, CO) and RUSSELL J. YUMA (Control Data Corp., Software Programs Div., Sunnyvale, CA) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 663-672.

The Multi-Vehicle Metric and Telemetry System (MMTS) is a complete range system which performs real-time tracking, command destruct, and telemetry processing functions for support of range safety and the test and evaluation of airborne vehicles. As currently configured, the MMTS consists of five hardware and software subsystems with the capability to receive, process, and display tracking data from up to ten range sensors and telemetry data from two instrumented vehicles. During a range operation, the MMTS is employed to collect, process, and display tracking and telemetry data. The instrumentation sites designated for operational support acquire tracking and telemetered data and transmit these data to the MMTS. The mission control area consists of a control and status console, high resolution color graphics stations, and large screen displays. As the mission controller observes mission progress on the graphics stations, operational decisions can be made and invoked by activation of the appropriate console controls. A unique feature of the MMTS is that telemetry data can be combined with tracking data for use by the range safety functions. Author

A89-31564
AUTOMATIC DEPENDENT SURVEILLANCE FOR OCEANIC AIR TRAFFIC CONTROL APPLICATIONS
PETER L. MASSOGLIA (FAA, Washington, DC) Navigation (ISSN 0028-1522), vol. 35, Winter 1988-1989, p. 397-406. refs

An FAA program to develop automatic dependent surveillance (ADS) as an enhancement for the Oceanic Display and Planning System (ODAPS) is discussed. The historical background of the National Airspace System and the developments leading to the ADS program are reviewed. The ODAPS is described, noting its functional limitations. The phases of ADS development are outlined and results from a demonstration of aircraft position reporting via satellite are given. R.B.

A89-31568
AIRCRAFT EXPERIENCES WITH A HYBRID LORAN-GPS
RALPH ESCHENBACH and MARK MORGENTHALER (Trimble Navigation, Sunnyvale, CA) Navigation (ISSN 0028-1522), vol. 35, Winter 1988-1989, p. 459-468. refs

During the past two years, a hybrid Loran-C/GPS receiver has been used in day-to-day navigation. The current capabilities and features of the hybrid receiver are discussed, with emphasis on the new digital Loran. Although the Loran receiver is designed as a marine product, many of the requirements of the aircraft market are similar. Data showing performance under several different circumstances are presented, including both static and dynamic performance. Future enhancements and capabilities are examined, with emphasis on the hybrid combination. Author

A89-31569
AIDING GPS WITH CALIBRATED LORAN-C
PER K. ENGE (Worcester Polytechnic Institute, MA) and JAMES R. MCCULLOUGH (Woods Hole Oceanographic Institution, MA) Navigation (ISSN 0028-1522), vol. 35, Winter 1988-1989, p. 469-482. Research supported by Megapulse, Inc. refs

The possibility of using Loran-C in conjunction with GPS is discussed, focusing on two methods for combining Loran pseudoranges with GPS pseudoranges in a position-fixing receiver. The theory of Loran propagation is reviewed and a basic Loran pseudorange model is presented. The approaches presented use a fixed data base to estimate the large portion of the Loran groundwave delay due to propagation over land. The approaches differ in the way that they handle the temporal variation in this propagation and the differential front-end delay. R.B.

A89-31907
A TASK-ORIENTED DIALOGUE SYSTEM - AN AERONAUTICAL APPLICATION [SYSTEME DE DIALOGUE ORIENTE PAR LA TACHE - UNE APPLICATION EN AERONAUTIQUE]
KARIM MATROUF, FRANCOISE NEEL, and JOSEPH MARIANI (CNRS, Laboratoire d'Informatique pour la Mecanique et les Sciences de l'Ingenieur, Orsay, France) Journal d'Acoustique (ISSN 0988-4319), vol. 2, March 1989, p. 85-93. In French. refs

A system for the spoken dialogue between a student air traffic controller and a air traffic simulator using the operative language employed between controllers and pilots is presented. Syntactic, semantic, and pragmatic knowledge is hierarchically represented. The present flexible and robust system is shown to be capable of minimizing the number of exchanges, as well as correcting errors due to poor recognition and to such factors as speaker mispronunciation or syntactic variations from standard phraseology. R.R.

N89-19283# Federal Aviation Administration, Washington, DC. Advanced System Design Service.
MINIMUM REQUIRED HELIPORT AIRSPACE UNDER VISUAL FLIGHT RULES Final Report
ROBERT D. SMITH Oct. 1988 25 p
(AD-A201433; DOT/FAA/DS-88/12; DOT/FAA/AS-89/1) Avail: NTIS HC A03/MF A01 CSCL 01E

Recently, the FAA started a flight measurement project to examine the issue of minimum required VFR airspace. Test data were collected objectively in a manner similar to what is done to define the minimum airspace for a precision approach. Heliport approach and departure flight profiles were recorded using a variety of subject pilots flying several different helicopters. Data were analyzed statistically to determine the mean, standard deviation, and 6 sigma isoprobability curves. Results of this effort are documented in FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. An analysis of the statistical distribution of these data is contained in FAA/CT-TN88/44, Analysis of Distributions of VFR Heliport Data. These test reports are not likely to be the last word on this topic but they should serve to focus the discussion on specific issues in a way that is constructive. This report is intended to focus discussion on how the data should be interpreted, some of the historical issues involved, and the direction to be taken in future work. GRA

N89-19284# Naval Ocean Systems Center, San Diego, CA.
THE EFFICACY OF COLOR-CODED SYMBOLS TO ENHANCE AIR-TRAFFIC CONTROL DISPLAYS Final Report
S. V. BEMIS, E. A. WINER, and J. L. LEEDS Aug. 1988 39 p
(AD-A201594; NOSC-TR-1244) Avail: NTIS HC A03/MF A01 CSCL 17G

This research tested the effect of color-coded air-traffic control displays on working memory and accuracy performance. Color, as a primary code and as a redundant code, was compared with shape coding under memory and no-memory conditions at varying density levels (5,8,11, and 14 symbols per display). In the shape-coded condition, symbol shapes denoted the altitude, or altitude and speed. All symbols had the same shape when color was used as a primary code. Only color denoted the altitude, or altitude and speed when color was tested redundantly. In the memory condition, subjects were required to remember the altitude and speed on each displayed symbol, and then sequence the planes in approach order to the landing area. Significant differences in recall accuracy occurred in the 8 and 11 symbol density displays. Compared to shape coding, color, either as a primary code or as a redundant code, significantly improved recall accuracy when altitude alone was encoded on each symbol. When both altitude and speed were encoded on each symbol, color as a redundant code significantly improved recall accuracy for the 8 and 11 symbol density levels. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A89-29160#
DESIGN OF A SMALL SUPERSONIC OBLIQUE-WING TRANSPORT AIRCRAFT
EGBERT TORENBEEK (Delft, Technische Universiteit, Netherlands) and ALEXANDER J. M. VAN DER VELDEN Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 193-197. refs

Previous work in the early 1970s has shown the merits of a (large) transonic oblique-wing transport. In this paper, the suitability of the oblique-wing planform for a small supersonic transport aircraft will be shown. The aircraft is designed to transport 24 passengers with first-class accommodations at a cruising speed of 1500 km/h over a distance of 5800 km. It complies to the JAR 25 and FAR 25 airworthiness requirements and the FAR 36 stage 3 noise regulations and is powered by two medium bypass turbofan engines. The proposed aircraft offers a typical increase in blockspeed of 53 percent at ranges of 4000-7000 km compared with similar small transport aircraft, with comparable fuel efficiency, range, and field performances. Author

A89-29170#
INTEGRATED DESIGN OF STRUCTURES
O. SENSBURG, G. SCHMIDINGER, and K. FUELLHAS (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 260-270. Previously announced in STAR as N87-22669. refs

It is shown that for highly sophisticated, naturally unstable airplanes flying supersonically a joint strategy to lay out the flight control system while minimizing design loads must be adopted. The selection of control surface geometry must be performed utilizing all possibilities from overall structural optimization including aeroelastic tailoring for primary carbon fiber structures. In the proposed design philosophy the behavior of the elastic airplane structure must be introduced and optimized in the very early design stage. It is shown that the required control surface hinge moments can be reduced by optimizing mass penalties and efficiencies. Minimizing installed hydraulic power supply has also had a beneficial effect on engine performance at low speed, high altitudes. Author

A89-29171*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECTS OF MODAL SYMMETRY ON TRANSONIC AEROELASTIC CHARACTERISTICS OF WING-BODY CONFIGURATIONS
GURU P. GURUSWAMY and EUGENE L. TU (NASA, Ames Research Center, Moffett Field, CA) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 781-793) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 271-280. Previously cited in issue 12, p. 1826, Accession no. A88-32256. refs

A89-29255#
ACTIVE NOISE REDUCTION IN A TRANSPORT AIRCRAFT CABIN
I. LEGRAIN (ONERA, Chatillon-sous-Bagneux, France) and M. GOULAIN (Aerospatiale, Toulouse, France) (Inter-Noise '88 Conference, Avignon, France, Aug. 30-Sept. 1, 1988) ONERA, TP, no. 1988-103, 1988, 5 p.
(ONERA, TP NO. 1988-103)

An active closed-loop noise-control system is described, which makes it possible to reduce the noise level of one particular acoustic mode whose frequency (usually between 50 and 60 Hz) corresponds with the fundamental frequency of the engine fan. The experimental control loop was tested in laboratory on a Concorde cabin section. Large noise reductions were obtained at the critical frequency. I.S.

A89-29348
NOTAR REDUCES PILOT WORKLOAD, IMPROVES RESPONSE IN OH-6A
NICHOLAS C. KERNSTOCK Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, Feb. 13, 1989, p. 44, 45, 47.

The no-tail-rotor, or 'Notar' system whose performance in application to the OH-6A helicopter is presently flight test-evaluated employs a circulation-control tailboom, a direct-jet thruster, and a variable-pitch fan, to collectively counteract main rotor torque and furnish directional control at low speeds and at hover. Impressively high yaw rates are noted to be possible with Notar; rates in excess of 100 deg/sec have been demonstrated with no loss of attitude control. Because the direct-jet thruster sleeve is not spring-loaded, and no other aerodynamic forces are changing the opening of the jet, control forces are noted to be very light. O.C.

A89-29349
UNCONVENTIONAL HELICOPTER TAIL ROTOR OFFERS FORWARD THRUST ADVANTAGE
WILLIAM B. SCOTT Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, Feb. 13, 1989, p. 49, 52.

The 'Tailfan' system, which replaces the standard helicopter tail rotor with a device that produces both forward thrust and antitorque control, significantly reduces power loadings and associated bending moments experienced by conventional helicopters' main rotor mast and blades at high forward speeds.

These ends are accomplished by means of a shaft-driven, tail-mounted device resembling a small turbofan, which propels the aircraft forward. The exhaust end of the fan duct is fitted with two semicircular doors, designated 'stabarons', which are hinged together along their common vertical diameter so that they can be closed, allowing the trapped air to be exhausted laterally for yaw control in specific flight regimes. In their open position, the stabarons form a small, thrust-vectoring rudder surface. O.C.

A89-29452* Virginia Polytechnic Inst. and State Univ., Blacksburg.

ANALYSIS AND RECONSTRUCTION OF HELICOPTER LOAD SPECTRA

A. K. KHOSROVANEH and N. E. DOWLING (Virginia Polytechnic Institute and State University, Blacksburg) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 18 p. refs

(Contract DAAJ02-85-C-0047; NAG1-822)

Notched metal test samples are presently subjected to helicopter load histories and the results obtained are compared to the fatigue-life predictions of a simplified version of the local-strain method. After studying the case of a peak/valley reconstructed history based on the standard spectrum, attention is given to a second, more irregular one based on actual flight data which is used to generate three reconstructed histories based on peak-valley, to-from, and rainflow characteristics. Comparisons indicate the rainflow cycle approach to be the most promising. O.C.

A89-29453

FOUNDATIONS OF AN ARMY HELICOPTER STRUCTURAL INTEGRITY PROGRAM

BARRY SPIGEL (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 12 p. refs

The specification of an overall degree of statistical reliability as a rotorcraft design goal is presently suggested to be a useful approach to the U.S. Army's establishing of design conservativeness in the formal standards and specifications encompassed by its helicopter structural integrity programs. A statistically-based design requirement is compatible with any given design methodology and allows the validation and evaluation of structural integrity; in addition, the in-service structural integrity results thus defined furnish a basis for determining logistics and fleet-planning requirements. O.C.

A89-29454

THE FUTURE ROLES OF FLIGHT MONITORS IN STRUCTURAL USAGE VERIFICATION

AUDBUR E. THOMPSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 13 p.

After evaluating past efforts in the implementation of rotorcraft in-flight structural monitoring sensors, prospective developments in fleet-wide, continuous structural usage monitoring sensors are discussed, in conjunction with the possibilities envisioned for regime-recognition software algorithms furnishing rate-of-occurrence data for all critical flight conditions. Attention is given to the results obtained to date for the flight data recorder installed aboard a developmental-testbed CH-53E Navy/Marine Corps heavy-lift helicopter; tail pylon stresses, primary servo load, load factor, total engine torque, main rotor speed, etc., are monitored by this recorder. O.C.

A89-29459

CRASH TESTING OF ADVANCED COMPOSITE ENERGY-ABSORBING, REPAIRABLE CABIN SUBFLOOR STRUCTURES

L. W. BARK, J. D. CRONKHITE (Bell Helicopter Textron, Inc., Fort Worth, TX), L. T. BURROWS (U.S. Army, Research and Technology Activity, Fort Eustis, VA), and L. M. NERI (FAA, Technical Center, Atlantic City, NJ) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p. refs

A readily-producible and repairable composite rotorcraft floor structure with energy-absorbing (EA) characteristics for crew/passenger crash threat minimization has been developed and tested. Three different AE concepts have been considered: a 'double-pandown' sandwich panel design, an integrally tube-stiffened design, and a sine-wave design; of these, the sandwich and the sine-wave were selected for drop testing in a full-scale cabin section. The EA capacity results thus obtained for the two alternatives were compared with results from the 'KRASH' analysis program. O.C.

A89-29465

KRASH ANALYSIS CORRELATION WITH THE BELL ACAP FULL-SCALE AIRCRAFT CRASH TEST

JAMES D. CRONKHITE (Bell Helicopter Textron, Inc., Fort Worth, TX) and L. T. MAZZA (U.S. Army, ACAP Project Office, Fort Eustis, VA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p.

The Bell ACAP aircraft, developed under the U.S. Army's Advanced Composite Airframe Program, was designed to meet the Army's stringent crash survivability requirements using the KRASH analysis combined with testing of critical energy-absorbing structural components. The full-scale aircraft was crash tested at the Impact Dynamics Facility of NASA Langley Research Center and successfully demonstrated that it provided crash protection for the occupants and fully met the ACAP crash requirements. The actual test condition was somewhat more severe than planned. Also, the onboard acceleration data was lost during the test and comparisons of the test results with the KRASH simulation had to be conducted using high speed photo motion analyses and post test measurements. For comparison purposes, the KRASH analysis was updated after the test to represent the actual test condition and to incorporate unexpected damage that had occurred to a tail gear fitting and the engine deck and were not included in the original analysis. Comparisons of the KRASH analysis and test showed good agreement and verified that KRASH was a viable analytical tool for the design of composite airframe structures for crash impact. Author

A89-29472

DESIGN, ANALYSIS AND TESTING CONSIDERATIONS OF FATIGUE-CRITICAL ROTORCRAFT COMPONENTS

BOGDON R. KRASNOWSKI, SATHY P. VISWANATHAN (Bell Helicopter Textron, Inc., Fort Worth, TX), and NORMAN E. DOWLING (Virginia Polytechnic Institute and State University, Blacksburg) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs

Three different analysis methods, namely, the classical safe-life method, the damage-tolerance method and the integrated method are discussed in terms of their typical design requirements, design analysis and the resulting reliability produced. The comparison is illustrated through a simple example problem of a plate with a hole subjected to random oscillatory load. The integrated method is shown as a method of analysis possessing features that are suitable for substantiating high reliability levels in fatigue-critical rotorcraft components. The importance of employing a local strain method in analyzing ground-air-ground (GAG) cycles is discussed and an example problem is solved. A rationale for including an appropriate number of GAG cycles in elevated load fatigue testing is discussed. Author

A89-29475
THE ON-CONDITION QUALIFICATION OF THE TRAILING EDGE AREA OF THE UH-1H METAL MAIN ROTOR BLADE
BILL DICKSON (Bell Helicopter Textron, Inc., Fort Worth, TX) and ROBERT ARDEN (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 12 p.

A program has been conducted by Bell Helicopter Textron, Inc. (BHTI), under contract to AVSCOM engineering, to establish an on-condition replacement status for the UH-1H metal main rotor blade considering fatigue cracking along the trailing edge. Two test specimens constructed from service-returned blades were used to generate crack growth data. Innovative approaches used in the test included application of a multistep spectrum of beamwise, chordwise, and torsional loads derived from the UH-1H operational spectrum to simulate a 2-hour flight. Application of test loads included the superposition of the significant 1/rev and 7/rev chordwise loads to realistically account for the dynamic response of the blade in flight. The paper presents details of the derivation of the crack growth test load spectrum, details of the test, and the crack growth data generated that were subsequently used to establish a safe inspection interval. Author

A89-29740
LANDING FLIGHT NEAR TRAFFIC LEVEL II USING THE IL-62M AIRCRAFT [LANDEANFLUEGE NACH BETRIEBSSTUFE II MIT DEM FLUGZEUGTYP IL-62M]
ADALBERT GLOECKNER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 6, 1988, p. 228-230. In German. refs

C.D.

A89-29961
HEAT-UP RATE EFFECTS OF REPAIR BONDING HELICOPTER ROTOR BLADES
L. R. PITRONE, S. R. BROWN (U.S. Navy, Naval Air Development Center, Warminster, PA), B. A. STEVINSON, and G. ELY (U.S. Navy, Naval Aviation Depot, San Diego, CA) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 108-119. refs

The heat-up limits for the repair bonding of helicopter rotor blades were investigated in experiments in which replacement pockets were bonded to a main rotor blade test spar using regular repair procedures except for the process heat-up rates, which varied in the range 2.7-44.0 F/min. The results of tests on the mechanical joint properties of specimens fabricated from repair-bonded rotor blade pocket-to-spar joints indicated that, for the heat-up rates evaluated, there was no significant difference in lap shear strength or Tg due to the difference in the heat-up rate; the results of peel srength tests disclosed a difference only between joints cured at 2.8 F/min and 44.0 F/min. Durability of the joints repaired with AF-163-20ST adhesive, as determined on wedge-crack specimens fabricated from the bonded rotor blade, showed no trend in crack growth rate or length over the heat-up rates studied. I.S.

A89-29974
STRUCTURAL DESIGN CONSIDERATIONS FOR FUTURE COMPOSITE TRANSPORT AIRCRAFT
TERRY TSUCHIYAMA and ARTHUR V. HAWLEY (Douglas Aircraft Co., Long Beach, CA) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 302-308.

The mechanical properties of state-of-the-art carbon/epoxy composites that limit the weight reduction potential in transport airframes are identified. A structural analysis conducted on an all-composite transport aircraft showed that stiffness, damage tolerance, and stress concentration properties all need to be dramatically increased. Ultimate strength, in both tension and compression, is not a significant driver in present designs. The paper demonstrates the potential for two or three specially optimized advanced composite materials to satisfy future transport airframe requirements. The approach used, and indeed, many of the conclusions have applicability to a wider field of aircraft types and structural components. Author

A89-30001
ARALL LAMINATE STRUCTURES - TOWARD THE SUPPORTABLE AND DURABLE AIRCRAFT
J. W. GUNNINK and L. B. VOGELESANG (Delft, Technische Universiteit, Netherlands) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 605-616. refs

Structural aspects of ARALL laminate are considered with special emphasis on durability, damage tolerance and supportability. It is shown that by applying ARALL laminates in the right way and on the right place the aircraft structure will be more durable and supportable. Author

A89-30659*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROSERVOELASTIC WIND-TUNNEL INVESTIGATIONS USING THE ACTIVE FLEXIBLE WING MODEL - STATUS AND RECENT ACCOMPLISHMENTS
THOMAS NOLL, BOYD PERRY, III, SHERWOOD TIFFANY, STANLEY COLE, CAREY BUTTRILL, WILLIAM ADAMS, JR., JACOB HOUCK, S. SRINATHKUMAR (NASA, Langley Research Center, Hampton, VA) et al. IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 68-79. refs
(AIAA PAPER 89-1168)

This paper describes the status of the joint NASA/Rockwell Active Flexible Wing Wind-Tunnel Test Program. The objectives of the program are to develop and validate the analysis, design and test methodologies required to apply multifunction active control technology for improving aircraft performance and stability. Major tasks of the program include designing digital multiinput/multioutput flutter-suppression and rolling-maneuver-load-alleviation concepts for a flexible full-span wind-tunnel model, obtaining an experimental data base for the basic model and each control concept, and providing comparisons between experimental and analytical results to validate the methodologies. This program is also providing the opportunity to improve real-time simulation techniques and to gain practical experience with digital control law implementation procedures. Author

A89-30674#
AEROELASTIC STABILITY OF AIRCRAFT WITH CIRCULATION CONTROL WINGS
DAVID J. HAAS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 218-229. refs
(AIAA PAPER 89-1184)

The flutter response of an aircraft configuration comprising a high-aspect-ratio wing with Coanda-effect circulation control (CC) and a rigid fuselage subject to pitch and plunge about the aircraft center of gravity is investigated analytically. The governing equations for CC aerodynamics are derived; the formulation of the linear time-domain unsteady-aerodynamics model on the basis of indicial response functions is outlined; the FEM implementation of the model using a two-node 6-DOF beam element is explained; and the results are presented in extensive graphs and characterized in detail. Low-speed flutter instabilities are predicted in both cantilevered-wing and free-free configurations at values of the CC blowing level and angle of attack for which stall is observed experimentally. T.K.

A89-30677#
AEROELASTIC STABILITY AND CONTROL OF A HIGHLY FLEXIBLE AIRCRAFT
A. H. VON FLOTOW (MIT, Cambridge, MA), M. C. VAN SCHOOR, and S. H. ZERWECKH IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 254-264. refs
(AIAA PAPER 89-1187)
The aeroelastic response of a human-powered aircraft with very flexible high-aspect-ratio wings is investigated analytically, applying an FEM approach based on beam elements and a two-dimensional-strip treatment of the aerodynamic surfaces. The theoretical bases and derivations of the structural-dynamic model, the unsteady-aerodynamics model, and the aeroelastic model are reviewed; the procedures used in the stability analysis are explained; and the results are presented in graphs and briefly characterized. The aircraft is shown to be generally stable (except for one moderately unstable phugoid mode) both at sea level and at high altitude. The applicability of the present analysis to long-endurance high-altitude aircraft is indicated. T.K.

A89-30679*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY EULER ALGORITHM WITH UNSTRUCTURED DYNAMIC MESH FOR COMPLEX-AIRCRAFT AEROELASTIC ANALYSIS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 275-284. refs
(AIAA PAPER 89-1189)
A finite-volume unstructured-grid FEM scheme with multistage Runge-Kutta time stepping is applied to the three-dimensional time-dependent Euler equations for inviscid flows on complex aircraft configurations undergoing structural deformation. The derivation of the model, the solution procedure, and the computer implementation are described, and results are presented graphically for a NASA Langley supersonic fighter aircraft model in steady and unsteady (harmonic oscillation in complete-vehicle bending mode) flow regimes. Good agreement between FEM predictions and experimental data is demonstrated. T.K.

A89-30713*# Texas Univ., Austin.
THERMO-VISCOPLASTIC ANALYSIS OF HYPERSONIC STRUCTURES SUBJECTED TO SEVERE AERODYNAMIC HEATING
EARL A. THORNTON, J. TINSLEY ODEN (Texas, University, Austin), W. WOYTEK TWORZYDLO, and SUN-KIE YOUN (Computational Mechanics Co., Inc., Austin, TX) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 604-620. Research supported by NASA and USAF. refs
(AIAA PAPER 89-1226)
A thermoviscoplastic computational method for hypersonic structures is presented. The method employs a unified viscoplastic constitutive model implemented in a finite element approach for quasi-static thermal-structural analysis. Applications of the approach to convectively cooled hypersonic structures illustrate the effectiveness of the approach and provide insight into the transient inelastic structural behavior at elevated temperatures. Author

A89-30714*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLUID-THERMAL-STRUCTURAL INTERACTION OF AERODYNAMICALLY HEATED LEADING EDGES
PRAMOTE DECHAUMPHAI, ALLAN R. WIETING (NASA, Langley Research Center, Hampton, VA), and AJAY K. PANDEY (Planning Research Corp., Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 621-631. refs
(AIAA PAPER 89-1227)
A two-dimensional finite element approach is presented for the integrated fluid-thermal-structural analysis of aerodynamically heated leading edges. The approach is combined with an adaptive unstructured remeshing technique to solve the Navier-Stokes equations for high speed compressible flow, the energy equation for the structure thermal response, and the quasi-static equilibrium equations for the structural response. Coupling and interaction between the three disciplines are demonstrated using two applications for high speed flow over a cylinder and a simulated engine leading edge verification test. V.L.

A89-30720#
APPLICATION OF PANEL METHOD AERODYNAMICS TO ROTOR AEROELASTICITY IN HOVER
OH JOON KWON and DEWEY H. HODGES (Georgia Institute of Technology, Atlanta) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 670-681. refs
(Contract DAAG29-82-K-0094; DAAL03-88-C-0003)
(AIAA PAPER 89-1234)
The paper is concerned with some of the computational issues related to the coupling of a three-dimensional lifting surface method with an elastic blade model. In particular, a thick-bladed panel method with prescribed tip-vortex geometry and iteratively calculated inner wake is applied to predict the steady-state response and aeroelastic stability of a hingeless rotor with elastic blades in the hovering flight condition. It is shown that the use of fully unsteady lifting surface aerodynamics with a realistic three-dimensional wake is important in calculating the unsteady lift and induced drag for the accurate prediction of low frequency rotor stability. V.L.

A89-30721#
INSIGHTS ON THE WHIRL-FLUTTER PHENOMENA OF ADVANCED TURBOPROPS AND PROPFANS
F. NITZSCHE (Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 682-690.
(AIAA PAPER 89-1235)
A 15-degree-of-freedom mathematical model is applied to the whirl-flutter problem for new aircraft configurations with two pusher propellers or propfans attached to the aft fuselage. The main stiffness properties of both the supporting back-up structure and the engine mounting system are systematically varied, and the mechanism of the whirl induced flutter is interpreted in simple physical terms. One of the important conclusions of the study is that an eventual degradation of the mount spring-rates may cause an unexpected improvement in the aircraft whirl-flutter margin against the previous damage tolerance airworthiness standard. V.L.

A89-30728#

NONLINEAR DAMPING ESTIMATION FROM ROTOR STABILITY DATA USING TIME AND FREQUENCY DOMAIN TECHNIQUES

FREDERICK A. TASKER and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 737-747. Research supported by the U.S. Army. refs

(AIAA PAPER 89-1243)

Modified versions of the moving-block analysis and sparse time domain techniques are applied to the estimation of nonlinear damping characteristics from rotor stability test data. The effects of several parameters on the identification process are examined through numerical simulations. The parameters include noise level, content of close harmonics, data length, block size, and quadratic and Coulomb damping. V.L.

A89-30749#

AIRCRAFT DESIGN OPTIMIZATION WITH MULTIDISCIPLINARY PERFORMANCE CRITERIA

STEPHEN J. MORRIS and ILAN KROO IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 909-919. refs

(AIAA PAPER 89-1265)

An integrated optimization procedure for aircraft design is presented in which multidisciplinary criteria are used as performance measures. The method presented here integrates the design of the aircraft and its control system in order to obtain better mission performance than could be achieved in a sequential design procedure. By minimizing a cost function consisting of both conventional performance criteria and a measure of aircraft handling qualities, a design with maximum performance for a specified level of handling can be achieved. Three example problems using this methodology are discussed. V.L.

A89-30750*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

SHAPE SENSITIVITY ANALYSIS OF FLUTTER RESPONSE OF A LAMINATED WING

RAKESH K. KAPANIA, FREDERICK D'OENCH BERGEN, JR. (Virginia Polytechnic Institute and State University, Blacksburg), and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 920-932. Previously announced in STAR as N89-11740. refs

(Contract NAS1-18471; NASA TASK 5)

(AIAA PAPER 89-1267)

A method is presented for calculating the shape sensitivity of a wing aeroelastic response with respect to changes in geometric shape. Yates' modified strip method is used in conjunction with Giles' equivalent plate analysis to predict the flutter speed, frequency, and reduced frequency of the wing. Three methods are used to calculate the sensitivity of the eigenvalue. The first method is purely a finite difference calculation of the eigenvalue derivative directly from the solution of the flutter problem corresponding to the two different values of the shape parameters. The second method uses an analytic expression for the eigenvalue sensitivities of a general complex matrix, where the derivatives of the aerodynamic, mass, and stiffness matrices are computed using a finite difference approximation. The third method also uses an analytic expression for the eigenvalue sensitivities, but the aerodynamic matrix is computed analytically. All three methods are found to be in good agreement with each other.

A89-30751#

AN INTEGRATED APPROACH TO THE OPTIMUM DESIGN OF ACTIVELY CONTROLLED COMPOSITE WINGS

E. LIVNE, L. A. SCHMIT, and P. P. FRIEDMANN (California, University, Los Angeles) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 933-945. refs

(Contract F49620-87-K-0003)

(AIAA PAPER 89-1268)

The synthesis of actively controlled composite wings is presented as a multidisciplinary optimization problem. A unique integration of analysis techniques spanning the disciplines of structures, aerodynamics, and controls is described. The computational efficiency and accuracy of the combined analysis indicate that one-level optimization of actively controlled composite wings is feasible. A rich variety of behavior constraints can be treated, including stress, displacement, natural frequency, aeroservoelastic stability, and handling-quality. The design space includes a simultaneous treatment of structural and control-system design variables. Author

A89-30752*# Analytical Services and Materials, Inc., Hampton, VA.

INTEGRATED AERODYNAMIC/DYNAMIC OPTIMIZATION OF HELICOPTER ROTOR BLADES

ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA), JOANNE L. WALSH (NASA, Langley Research Center, Hampton, VA), and MICHAEL F. RILEY (Planning Research Corp., Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 946-958. refs

(AIAA PAPER 89-1269)

An integrated aerodynamic/dynamic optimization procedure is used to minimize blade weight and 4/rev vertical shear of a rotor blade in forward flight. Both single and multiple objective functions are used, with constraints imposed on the first four coupled natural frequencies (elastic modes only), the blade aerorotational inertia, and the centrifugal stress. The global criteria approach is used for the multiple objective formulation, and the results are compared with those obtained from single objective function formulations. Optimum designs are compared against a reference blade, and it is shown that optimum results can be obtained in 7-10 cycles. V.L.

A89-30753#

OPTIMUM DESIGN OF HELICOPTER ROTORS FOR LONGITUDINAL HANDLING QUALITIES IMPROVEMENT IN FORWARD FLIGHT

ROBERTO CELI (Maryland, University, College Park) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 959-967. Research supported by the U.S. Army. refs

(AIAA PAPER 89-1270)

The possibility of designing a hingeless rotor helicopter that is longitudinally stable because of the stabilizing effect of the rotor is investigated using a multidisciplinary optimization approach, with a flight mechanics related objective function and behavior constraints associated with both the flight mechanics and the aeroelastic characteristics of the helicopter. The objective is the minimization of the real part of the unstable complex conjugate pair of eigenvalues, which appears in the calculation of the longitudinal flight stability. The optimization procedure described here is efficient, converges rapidly, and requires a small number of analyses to generate acceptable designs. V.L.

A89-30786#
DYNAMICAL BEHAVIOR OF A NONLINEAR ROTORCRAFT MODEL
GEORGE T. FLOWERS (South Florida, University, Tampa) and BENSON H. TONGUE (California, University, Berkeley) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1287-1294. refs
(AIAA PAPER 89-1306)

The term 'air resonance' refers to an instability associated with helicopters in hover and forward flight. It is characterized by a coupling between motions of the fuselage and the blades and is of primary concern for helicopters having soft in-plane rotors. This paper investigates the effect of nonlinearities on the dynamical behavior of a simplified air resonance model. For comparison purposes, a linear analysis of the air resonance model is first developed. Two further studies are then performed. The fully nonlinear air resonance model is analyzed for the effect of geometric and discrete nonlinearities and the responses compared those of the linearized model. In addition, a flap-lag model excited by a harmonic oscillation of the blade pitching angle is considered and the responses examined for chaotic behavior. Author

A89-30797#
AEROELASTIC DESIGN OF A COMPOSITE WING WITH WIND TUNNEL INVESTIGATION
WILLIAM J. NORTON (USAF, Edwards AFB, CA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1384-1393. refs
(AIAA PAPER 89-1320)

The effects of composite laminate fiber orientation on the aeroelastic characteristics of various aircraft wing configurations is investigated by analytical and experimental means. Many wings of varied planform and control surface configurations are analyzed using beam theory as a parametric analysis. The analysis is then tested using a wind tunnel model of a half-span configuration fashioned from graphite fiber reinforced resin matrix composite plates. The experiment shows that beam theory is unsuitable for this application; however, valuable empirical data is obtained. S.A.V.

A89-30798*# California Univ., Los Angeles.
ANALYTIC SIMULATION OF HIGHER HARMONIC CONTROL USING A NEW AEROELASTIC MODEL
P. P. FRIEDMANN (California, University, Los Angeles) and L. H. ROBINSON IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1394-1406. Research supported by the McDonnell Douglas Helicopter Co. refs
(Contract NAG2-477)
(AIAA PAPER 89-1321)

This paper describes a higher harmonic control (HHC) study of a four bladed hingeless rotor using a coupled flap-lag-torsional aeroelastic stability and response analysis which incorporates finite-state, time-domain aerodynamics. The rotor trim condition is determined using a coupled trim-aeroelastic analysis. Deterministic and cautious controllers based on local and global HHC models are implemented with different combinations of input parameters identified using a Kalman filter. The effects of unsteady versus quasisteady aerodynamic modeling on HHC simulations are investigated, including the effectiveness of the local and global HHC models and the advantages of different identification schemes. Author

A89-30801*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
METHOD FOR EXPERIMENTAL DETERMINATION OF FLUTTER SPEED BY PARAMETER IDENTIFICATION
E. NISSIM and G. B. GILYARD (NASA, Flight Research Center, Edwards, CA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1427-1441. refs
(AIAA PAPER 89-1324)

A method for flight flutter testing is proposed which enables one to determine the flutter dynamic pressure from flights flown far below the flutter dynamic pressure. The method is based on the identification of the coefficients of the equations of motion at low dynamic pressures, followed by the solution of these equations to compute the flutter dynamic pressure. The initial results of simulated data reported in the present work indicate that the method can accurately predict the flutter dynamic pressure, as described. If no insurmountable difficulties arise in the implementation of this method, it may significantly improve the procedures for flight flutter testing. Author

A89-30802*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOME LOW-SPEED FLUTTER CHARACTERISTICS OF SIMPLE LOW-ASPECT-RATIO DELTA WING MODELS
ROBERT V. DOGGETT, JR. (NASA, Langley Research Center, Hampton, VA) and DAVID L. SOISTMANN (Planning Research Corp., Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1442-1450. refs
(AIAA PAPER 89-1325)

Some results from a combined experimental and analytical study of the low-speed flutter characteristics of low-aspect-ratio delta wings are presented. Data are presented which show the effects of sweep angle on the flutter characteristics of some simple plate models of constant planform area. The range of sweep angles studied was from 30 to 72 degrees. In addition, flutter results are presented for two 30 deg-sweep clipped-delta wing models. Further results are presented that show the effects of root clamping (percentage length of the root chord that is cantilevered) for a 45 deg-sweep delta wing. The experimental data are compared with analytical results obtained by using kernel function and doublet lattice subsonic unsteady lifting surface theories. Author

A89-30834#
SONIC FATIGUE LIFE INCREASE OF THE A-10 GUNBAY
KENNETH R. WENTZ (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1759-1764.
(AIAA PAPER 89-1359)

High intensity gunfire pressure pulses have caused structural fatigue in the forward fuselage area of A-10 aircraft. The Flight Dynamics Laboratory conducted a program to inhibit the occurrence of the structural fatigue through the application of a passive damping system. A flight test verified that the damping treatment provided enough dynamic stress reduction in the gunbay structure to achieve the desired service life. The program was sponsored by the Sacramento Air Logistics Center. Author

A89-30848*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NACA/NASA RESEARCH RELATED TO EVOLUTION OF U.S. GUST DESIGN CRITERIA
HAROLD N. MURROW, KERMIT G. PRATT, and JOHN C. HOUBOLT (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1869-1882. refs
(AIAA PAPER 89-1373)

This paper traces the evolution of gust design criteria in the U.S. particularly from the standpoint of research that was used in the substantiation for the various versions in the evolution. The mathematical models of airplanes and of atmospheric turbulence and their rationale are described. Emphasis is given to the revisions and refinements made starting in the 1920's up to the present time. The major steps, beginning with the sharp edged gust formula, are traced through the modified formula specifying ramp-platform gusts and later to one-minus-cosine gusts and finally to criteria for continuous gust analyses. The influence of aircraft design developments on design criteria development needs is also addressed. A brief summary of military criteria is included. Significant discussion is devoted to measurements that have been made, including onboard recordings, to provide an extensive data base of (1) atmospheric turbulence experienced in routine flight operations, (2) specially-instrumented research aircraft measurements to provide atmospheric characterization for various flight and meteorological conditions, and (3) comparisons of measured and calculated aircraft responses in turbulence. Some features of the instrumentation used will be depicted. Author

A89-30849*# Planning Research Corp., Hampton, VA.
TIME-CORRELATED GUST LOADS USING MATCHED FILTER THEORY AND RANDOM PROCESS THEORY - A NEW WAY OF LOOKING AT THINGS
ANTHONY S. POTOTZKY, THOMAS A. ZEILER (Planning Research Corp., Aerospace Technologies Div., Hampton, VA), and BOYD PERRY, III (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1883-1891. refs
(AIAA PAPER 89-1374)

This paper describes and illustrates two ways of performing time-correlated gust-load calculations. The first is based on Matched Filter Theory; the second on Random Process Theory. Both approaches yield theoretically identical results and represent novel applications of the theories, are computationally fast, and may be applied to other dynamic-response problems. A theoretical development and example calculations using both Matched Filter Theory and Random Process Theory approaches are presented. Author

A89-30850#
THE STATISTICAL DISCRETE GUST (SDG) METHOD IN ITS DEVELOPED FORM
J. G. JONES (Royal Aerospace Establishment, Farnborough, England) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1892-1898. refs
(AIAA PAPER 89-1375)

The paper reviews the current status of the statistical discrete gust method for predicting aircraft response to atmospheric gusts and turbulence. In the case of continuous turbulence, numerical parameters can be chosen to obtain an equivalence between the SDG and PSD methods. However, this equivalence breaks down for relatively isolated extreme gusts. Changes in numerical parameters required to represent extreme gusts are described and phenomena that can arise in the stochastic response of nonlinear systems are discussed. Author

A89-30852#
PREDICTION OF TAIL BUFFET LOADS FOR DESIGN APPLICATION
N. H. ZIMMERMAN, M. A. FERMAN, R. N. YURKOVICH (McDonnell Aircraft Co., Saint Louis, MO), and G. GERSTENKORN (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1911-1919. Research supported by the U.S. Navy. refs
(AIAA PAPER 89-1378)

Two techniques, designated the 'flexible tail' and 'rigid tail' pressure methods, are presently developed for the design-stage prediction of empennage buffet aerodynamic behavior in advanced aircraft flying at high angles-of-attack. The intention of the methods is to furnish structural design guidance toward the avoidance of buffet-response damage, or the avoidance of further damage when unexpected buffet response is encountered. Both methods are validated in light of wind tunnel and F/A-18 flight data. It is found that there is a distinct peak in the pressure spectrum that scales with reduced frequency, and that the region of high empennage buffet pressure occurs in regions of relatively low dynamic pressure and Mach number. O.C.

A89-30858*# Planning Research Corp., Hampton, VA.
RESULTS OF A PARAMETRIC AEROELASTIC STABILITY ANALYSIS OF A GENERIC X-WING AIRCRAFT
JESSICA A. WOODS (Planning Research Corp., Hampton, VA), MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA), and TERRENCE A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1973-1981. refs
(AIAA PAPER 89-1385)

This paper discusses the trend in longitudinal dynamic aeroelastic stability of a generic X-Wing aircraft model with design parameter variations. X-Wing rotor blade sweep angle, ratio of blade mass to total vehicle mass, blade structural stiffness cross-coupling and vehicle center-of-gravity location were parameters considered. The typical instability encountered is body-freedom flutter involving a low frequency interaction of the first elastic mode and the aircraft short period mode. Parametric cases with the lowest static margin consistently demonstrated the highest flutter dynamic pressures. As mass ratio was increased, the flutter boundary decreased. The decrease was emphasized as center-of-gravity location was moved forward. As sweep angle varied, it was observed that the resulting increase in forward-swept blade bending amplitude relative to aft blade bending amplitude in the first elastic mode had a stabilizing effect on the flutter boundary. Finally, small amounts of stiffness cross-coupling in the aft blades increased flutter dynamic pressure. Author

A89-30879#
OVERVIEW - DESIGN OF AN EFFICIENT LIGHTWEIGHT AIRFRAME STRUCTURE FOR THE NATIONAL AEROSPACE PLANE
DAVID A. ELLIS (McDonnell Douglas Corp., Saint Louis, MO) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 2157-2163.
(AIAA PAPER 89-1406)

Aspects in the design of a lightweight National Aerospace Plane (NASP) vehicle are considered. Some of the major aspects of the integration process from the airframe design perspective are addressed, with specific emphasis on the interaction between design, strength, thermodynamics, and loads disciplines. An overview of the analyses performed and preliminary results of structure and materials trade studies of several major airframe structure components are presented. The types of trade studies conducted, the implication of the results, and the interdisciplinary interaction required to produce a successful end-product are discussed. S.A.V.

A89-30880#
ELEVATED TEMPERATURE ALUMINUM ALLOYS FOR ADVANCED FIGHTER AIRCRAFT
J. C. EKVALL, R. A. RAINEN, D. J. CHELLMAN (Lockheed Aeronautical Systems Co., Burbank, CA), R. R. FLORES (USAF,

Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and M. J. GERSBACH (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 2164-2171. refs
(AIAA PAPER 89-1407)

Materials property data are presented on various elevated temperature aluminum alloys in sheet, extrusion, and forging product forms. These materials are being considered for applications in the aft fuselage of an advanced tactical fighter aircraft. A design trade study is conducted for a center keel beam component between the engine compartments. Weight and cost comparisons are made for this application using elevated temperature aluminum alloys, an Al/SiC metal matrix composite (MMC), and graphite/polyimide composite in lieu of titanium. Results show potential weight and cost savings of 12.8 and 46.5 percent, respectively, for a structure fabricated from elevated temperature aluminum alloys as opposed to titanium alloys. Additional weight and cost savings can be achieved using hot molded MMC Al/SiC beam caps. S.A.V.

A89-30892#
FORWARD FLIGHT AEROELASTICITY OF A HINGELESS ROTOR BLADE BY BILINEAR FORMULATION
NITHIAM TI SIVANERI and GRZEGORZ KAWIECKI (West Virginia University, Morgantown) AIAA, ASME, ASCE, AHS, and ASC, Srtuctures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989. 9 p. refs
(AIAA PAPER 89-1233)

The steady state response of flap bending, lead-lag bending and torsion of a hingeless helicopter rotor blade in forward flight is modeled with a system of coupled nonlinear differential equations in space and time domain. In this paper, an approximate solution is obtained with a time-finite-element method based on a bilinear approach. The blade is discretized into beam elements, each with fifteen degrees of freedom. Aerodynamic forces are obtained using quasi-steady blade strip theory. The blade finite element response equations are transformed to the modal space using a few main normal modes. A periodical response solution for a selected blade configuration is presented. Author

A89-30976
DETECTION, DIAGNOSIS AND PROGNOSIS OF ROTATING MACHINERY TO IMPROVE RELIABILITY, MAINTAINABILITY, AND READINESS THROUGH THE APPLICATION OF NEW AND INNOVATIVE TECHNIQUES
T. ROBERT SHIVES, ED. (NIST, Gaithersburg, MD) and LAWRENCE J. MERTAUGH, ED. (U.S. Navy, Naval Air Test Center, Patuxent River, MD) Cambridge and New York, Cambridge University Press, 1988, 411 p. For individual items see A89-30977 to A89-30997.

The conference presents papers on the evaluation of an on-line ultrasonic particle sensor using bearing test data, a diagnostic aid for engine gas path particle analysis, the effects of vibration sensor location in detecting gear and bearing defects, modal frequency theory of fracture damage diagnosis in structures, and gear failure analysis in helicopter main transmissions using vibration signature analysis. Other topics include gear failure analyses in helicopter main transmissions using vibration signature analysis, compact diagnostic coprocessors for avionic use, and the development of an onboard maintenance computer for the AH-64. Consideration is also given to the study of wear-corrosion in a dynamic electrochemical cell, knowledge-based jet engine diagnostics using XMAN, and an expert system for O-ring selection and gland design. K.K.

A89-30978
EVALUATION OF VIBRATION ANALYSIS TECHNIQUES FOR THE DETECTION OF GEAR AND BEARING FAULTS IN HELICOPTER GEARBOXES
LAWRENCE J. MERTAUGH (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 44-48.

The use of vibration analysis for the detection of gear and bearing faults within complex gearboxes has been proposed for many years. The objectives of the study effort discussed in this paper are to provide an assessment of the analysis techniques currently available and to identify those areas of development that need to be pursued in order that a feasible operational detection system may be provided. This paper will discuss findings regarding the availability of adequate design information and will present the results of testing conducted with seeded faults on a relatively simple helicopter gearbox. Needed research will be described. Author

A89-30984
GEAR FAILURE ANALYSES IN HELICOPTER MAIN TRANSMISSIONS USING VIBRATION SIGNATURE ANALYSIS
DIMITRI A. DOUSIS (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 133-144. refs

The paper presents the results from vibration signature analyses of Model 400 and Model 412 helicopter main rotor transmissions during fatigue tests under a 140 percent overtorque condition. The analysis of the signals which caused rapid deterioration of gears revealed that the overmechanical condition of the gear can be monitored by trending vibration data. Epicyclic and bevel gears are studied as well as trending of fundamental gearmesh, gearmesh harmonics vibration amplitude, and ratios of gearmesh harmonics to fundamental and sideband ratios. K.K.

A89-30985
VIBRATION ANALYSIS FOR DETECTION OF BEARING AND GEAR FAULTS WITHIN GEARBOXES - AN INNOVATIVE SIGNAL PROCESSING APPROACH
R. C. KEMERAIT, G. W. POUND, and L. J. OWIESNY (ENSCO, Inc., Melbourne, FL) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 145-159. refs

The possibility of enhancing the early detection of gear and bearing problems in helicopter gearboxes utilizing more sophisticated signal processing techniques was studied. Acceleration data collected from a U.S. Navy TH 1L helicopter test bed were processed. Particular attention was given to potential improvements to be gained by utilizing the complex and cosine-squared cepstrum techniques. It is confirmed that any spectral line change of 6 dB is reason for concern and that a 10 dB change is reason for panic. K.K.

A89-30988
VIBRATION HEALTH MONITORING OF THE WESTLAND 30 HELICOPTER TRANSMISSION - DEVELOPMENT AND SERVICE EXPERIENCE
DEREK G. ASTRIDGE (Westland Helicopters, Ltd., Yeovil, England) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 200-215. refs

The application of a new type of vibration analysis (enhanced signal averaging) to the Westland 30 helicopter transmission is described. This type of analysis can be used to detect the distributed surface damage on gears. The implementation developments in the form of the portable analyzer and the on-board system can complement effective on-line wear debris monitoring systems which are the preferred means of detecting surface wear modes in bearings and gears. K.K.

A89-30989
HELICOPTER GEAR BOX CONDITION MONITORING FOR AUSTRALIAN NAVY
K. F. FRASER and C. N. KING (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 216-225. refs

A fatigue life usage indicator (FLUI) system was developed to provide data for estimating the fatigue life usage per operating hour of various sortie types for RAN Sea King main transmission system gears under normal operating conditions. The FLUI provides data which can be used in assessing the severity of and fatigue life usage resulting from rare overtorquing incidents. Operational load data gathered by the fatigue life usage indicating system are of great value to the helicopter manufacturer for the design and life estimation of components. K.K.

A89-30990
ENGINE AND TRANSMISSION MONITORING - A SUMMARY OF PROMISING APPROACHES
JOSEPH PRATT (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 229-236. refs

Prospective approaches to the integrated monitoring of engines and transmissions are presented. Monitor system requirements were developed in the following technology areas: advanced sensors, synergistic handling of data, artificial intelligence, and new microproccessor architectures for parallel processing to achieve real-time capability. Consideration is also given to current engine monitoring methods, such as automatic performance monitoring, cycle counting for life assessment, and engine parameter trend monitoring. K.K.

A89-30994
HOW TO GET THE DESIGNER INTO THE BOX
R. M. STEWART, I. C. CHEESEMAN, and D. G. BONFIELD (Stewart Hughes, Ltd., Southampton, England) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 280-291.

How to build the helicopter designer into its monitoring and diagnostic computer is addressed. Past generations of helicopters have tended to have had their monitoring devices added as an afterthought (diagnostics being absolutely unheard of). So, with diagnostic theory advancing at the rate it is, coupled to astonishing advances in computer power per cubic inch, it would indeed be a pity if the next generation of machines (e.g. LHX) did no better. It is believed that a key aspect of this will be to get the designer's thought processes into the onboard diagnostic computer. Three possible routes are suggested. Author

A89-30997
COMPUTER ASSISTED TRACK AND BALANCE SAVES FLIGHTS
LAWRENCE D. BARRETT and D. SHAW SIGLIN (Boeing Vertol Co., Philadelphia, PA) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 351-360.
(Contract DAAJ09-85-G-A014; N00014-82-D-5041)

It is found that application of the Vibrex track and balance equipment to the CH-46 and CH-47 helicopters produced quantified data relating blade adjustments to rotor vibrations. On the basis of these data, computer programs were prepared which used the rotor vibration characteristics as input. The use of a preprogrammed pocket computer to supplement the Vibrex equipment and define the required track and balance corrections is described. K.K.

A89-31099
IL-96 - A GLASNOST VIEW
Air International (ISSN 0306-5634), vol. 36, March 1989, p. 125-131.

A development history, design features presentation, and performance capabilities evaluation are presented for the Il-96 wide-body airliner that entered Aeroflot service in September, 1988. This six- to nine-abreast seating (depending on class) configuration employs four high-bypass turbofans and incorporates such state-of-the-art features as winglets and a six-CRT flight instrumentation display system; the cockpit layout is, however, for the conventional crew of three rather than a more automated cockpit's two crewmembers. A maximum passenger carriage of 300 is achievable in a single (business) class cabin layout at a seat pitch of 87 cm, with nine-abreast seating arranged in three groups of three seats with two intervening aisles. O.C.

A89-31307
ON THE CONTINUED GROWTH OF CFD IN AIRPLANE DESIGN
PAUL E. RUBBERT (Boeing Co., Seattle, WA) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 103-115. refs

Computational Fluid Dynamics (CFD) is beginning to stand alongside the wind tunnel in terms of importance for aerodynamic design. As CFD usage continues to grow, its value becomes increasingly evident, and this is providing the stimulus and demand for further CFD developments. The paper describes the changes that have occurred since the inception of CFD, the present role of CFD in aerodynamic design, today's research focus, and prospects for the future. Some examples are given which illustrate the impact that CFD has had on airplanes that have recently entered service. Author

A89-31338
THE OPTIMUM-OPTIMORUM THEORY AND ITS APPLICATION TO THE OPTIMIZATION OF THE ENTIRE SUPERSONIC TRANSPORT AIRCRAFT
ADRIANA NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 557-568. refs

The optimum-optimorum aircraft configuration is the configuration for which the shapes of its surface and also of its plan projection are simultaneously determined in such a manner that its drag functional (with free boundary) attains its minimum at a given cruising Mach number. The problem of the determination of the configuration of an aircraft of variable geometry of minimum drag at two cruising Mach numbers is also considered. Author

A89-31461*# Georgia Inst. of Tech., Atlanta.
FLIGHT-TEST MANEUVER MODELING AND CONTROL
P. K. A. MENON (Georgia Institute of Technology, Atlanta), R. A. WALKER (FMC Central Engineering Laboratory, Santa Clara, CA), and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 195-200. Previously cited in issue 07, p. 844, Accession no. A86-19868. refs
(Contract NAS2-11877)

A89-31757
A PERSPECTIVE ON MODELLING ROTORCRAFT IN TURBULENCE
GOPAL H. GAONKAR (Florida Atlantic University, Boca Raton) Probabilistic Engineering Mechanics (ISSN 0266-8920), vol. 3, March 1988, p. 36-42. refs

The turbulence as experienced by a blade station requires a non-Eulerian and rotationally-sampled description, referred to as the rotating frame turbulence (RFT). The RFT excites each blade with basic and higher harmonics. The RFT, with its energy shift to and the peaks centered about the basic and higher frequencies, is fundamental to the investigation of gust-induced stability and vibration. A generalized treatment of turbulence in the rotor disk is provided which is applicable to conventional helicopters from axial flight to high-speed forward flight conditions. The RFT shows the occurrence of peaks and the consequent transfer of energy to the high-frequency region for the stationary and nonstationary cases. S.A.V.

A89-31827#
AEROELASTIC TESTS AND CALCULATIONS FOR LIGHT AIRCRAFT [ESSAIS ET CALCULS AEROELASTIQUES DES AVIONS LEGERS]
G. PIAZZOLI (ONERA, Chatillon-sous-Bagneux, France) ONERA, TP, no. 1988-169, 1988, 22 p. In French.
(ONERA, TP NO. 1988-169)
The aeroelastic analysis of light aircraft based on the study of vibrational behavior and the mechanisms of dynamic instability is considered. The modal characteristics of light aircraft are determined using either an adaptation of the classical method of multiexcitations or a mathematical model for the smoothing of transfer functions. The effect of the control surfaces on the different structural modes is studied by a combination of experimental and theoretical methods. Aerodynamic, pyrotechnic, and inertial techniques for the experimental determination of the vibrational behavior of light aircraft are also discussed. R.R.

A89-31858*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PARTITIONING OF FLIGHT DATA FOR AERODYNAMIC MODELING OF AIRCRAFT AT HIGH ANGLES OF ATTACK
JAMES G. BATTERSON (NASA, Langley Research Center, Hampton, VA) and VLADISLAV KLEIN (George Washington University, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 334-339. Previously cited in issue 22, p. 3534, Accession no. A87-49621. refs

A89-31859#
VELOCITY MEASUREMENTS OF AIRFRAME EFFECTS ON A ROTOR IN A LOW-SPEED FORWARD FLIGHT
S. G. LIOU, N. M. KOMERATH, and H. M. MCMAHON (Georgia Institute of Technology, Atlanta) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 340-348. Previously cited in issue 07, p. 946, Accession no. A88-22496. refs
(Contract DAAG29-82-K-0084)

A89-31861#
SURFACE-BLOWING ANTI-ICING TECHNIQUE FOR AIRCRAFT SURFACES
A. H. TABRIZI (Indiana Institute of Technology, Fort Wayne) and W. S. JOHNSON (Tennessee, University, Knoxville) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 354-359. refs
An experimental evaluation of surface blowing as an antiicing technique applicable to aircraft surfaces is presented. A circular cylinder was used to approximate the leading edge of an aircraft icing surface utilizing a number of slots located at the frontal surface along the cylinder to inject air counter to the main air-droplet stream. The effects of air blowing for single and multiple slots as well as the effect of air injection rates on the reduction of ice accretion rate are reported. The experimental results indicate that surface blowing produces a general reduction in ice buildup.
Author

A89-31863#
FLUTTER OF CIRCULATION CONTROL WINGS
DAVID J. HAAS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and INDERJIT CHOPRA (Maryland, University, College Park) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 1065-1076) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 373-381. Previously cited in issue 12, p. 1826, Accession no. A88-32286. refs

A89-31865#
EFFECT OF CENTRIFUGAL FORCE ON RANGE OF THE AERO-SPACE PLANE
CHARLES W. BERT (Oklahoma, University, Norman) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 393-395. refs
As the X-30 hypersonic cruise aircraft approaches speeds that are a significant fraction of orbital speed, it becomes necessary to factor the effects of centrifugal force on cruising range, and hence on overall design. The present cruising range calculations proceed on the basis of a predetermined flight strategy and fuel-consumption model. Equations are presented which demonstrate that the optimal Mach number for achievement of maximum range in orbit is that at which thrust-specific fuel consumption has its minimum. O.C.

A89-31866*# Florida Univ., Gainesville.
OPTIMUM STRUCTURAL SIZING FOR GUST-INDUCED RESPONSE
P. HAJELA and C. T. BACH (Florida, University, Gainesville) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 681-688) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 395-397. Previously cited in issue 12, p. 1825, Accession no. A88-32248. refs
(Contract NAG1-688)

N89-18445# Naval Postgraduate School, Monterey, CA.
AN EXPERIMENTAL INVESTIGATION OF A FIGHTER AIRCRAFT MODEL AT HIGH ANGLES OF ATTACK M.S. Thesis
DAVID H. LEEDY Sep. 1988 168 p
(AD-A201993) Avail: NTIS HC A08/MF A01 CSCL 01C
A low speed wind tunnel investigation was conducted to examine the aerodynamic characteristics of the flowfield around a three percent scale YF-17 lightweight fighter prototype model at high angles of attack using flow visualization and force and moment measurements. Smoke filaments, injected into the wind tunnel test section, were illuminated by a laser sheet to highlight flow phenomena about the model. Force and moment measurements were made using a precision six-component strain gage balance. The investigation marked the first attempt at qualitative flow analysis using the laser sheet flow visualization system recently installed in the Naval Postgraduate School low speed wind tunnel facility. The investigation was undertaken to specifically identify flow phenomena and/or regions of interest that may have bearing on the design and performance of supermaneuverable aircraft. The data indicate a good correlation between the observed flow phenomena and force and moment measurements at various angles of attack, thus establishing the credibility of such experimental investigations for high angle of attack aerodynamic research. GRA

N89-18652# Royal Aircraft Establishment, Farnborough (England).
THE DESIGN OF THE GARTEUR LOW ASPECT-RATIO WING FOR USE IN THE VALIDATION OF SHEAR LAYER AND OVERALL FLOW PREDICTION METHODS
M. C. P. FIRMIN and M. A. MCDONALD *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 17 p Dec. 1988
Avail: NTIS HC A11/MF A01
A low aspect-ratio wing has been designed for use in the critical analysis of computational methods for three-dimensional shear layers, following the guidelines agreed by GARTEUR Action Group AD(AG07). The aim here is to give details of the design processes used and to indicate the flow conditions which will be explored in the detailed shear-layer tests to be made in the NLR LST (3.0 x 2.25 m) and ONERA (1.8 x 1.4 m) low-speed wind tunnels, as part of the GARTEUR program. Calculations have been

made, using a selection of boundary layer methods which indicate that the design should provide very challenging tests for methods. Pilot model tests have suggested that the wing has been designed successfully and these have encouraged the Action Group to proceed with the main test program. Author

N89-18654# Defence Research Establishment Valcartier (Quebec). Ballistics Group.

VALIDATION OF A USER-FRIENDLY CFD CODE FOR PREDICTION OF THE AERODYNAMIC CHARACTERISTICS OF FLIGHT VEHICLES

MICHEL FORTIER *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 19 p Dec. 1988

Avail: NTIS HC A11/MF A01

A computational fluid dynamics code based on the development of small perturbation theory for the solution of inviscid irrotational compressible fluid flow around flight vehicle configurations is described. The user-friendly feature of the code is illustrated by a guided weapon canard configuration for which are displayed computed pressure distributions on selected components. Five test cases including a simple wing shape and more complex guided weapon and aircraft configurations are presented to demonstrate the capabilities and limitations of the code. Theoretical pressure, force and moment coefficients are compared to wind tunnel data obtained from various facilities. The results of the comparison show the capabilities of the code in the subsonic and supersonic speed regimes for simple and complex configurations at low incidences, and its limitations at transonic speeds and at high angles of attack. Author

N89-19238*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CAP-TSD: A PROGRAM FOR UNSTEADY TRANSONIC ANALYSIS OF REALISTIC AIRCRAFT CONFIGURATIONS

JOHN T. BATINA, DAVID A. SEIDEL, SAMUEL R. BLAND, and ROBERT M. BENNETT *In its* Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 1 p 63-95 Feb. 1989

Avail: NTIS HC A12/MF A01 CSCL 01C

The development of a new transonic code to predict unsteady flows about realistic aircraft configurations are described. An approximate factorization algorithm for solution of the unsteady transonic small disturbance equation is first described. Because of the superior stability characteristics of the AF algorithm, a new transonic aeroelasticity code was developed which is described in some detail. The new code was very easy to modify to include the additional aircraft components, so in a very short period of time the code was developed to treat complete aircraft configurations. Finally, applications are presented which demonstrate many of the geometry capabilities of the new code. Author

N89-19239*# McDonnell Aircraft Co., Saint Louis, MO.

CAP-TSD ANALYSIS OF THE F-15 AIRCRAFT

DALE M. PITT *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 1 p 97-116 Feb. 1989

Avail: NTIS HC A12/MF A01 CSCL 01C

The F-15 fighter aircraft was modeled using Computational Aeroelasticity Program - Transonic Small Disturbance (CAP-TSD). The complete aircraft was modeled including the wing, stabilator, flow through inlets, and fuselage body. CAP-TSD was used to make static pressure runs for Mach numbers of 0.8, 0.9, 0.95 and 1.2. The angle of attack for these runs ranged from 0 to 5 degs. The CAP-TSD program showed good agreement between the computed fuselage and wing pressures and the measured wind tunnel pressures. Including the fuselage and inlets in the CAP-TSD analysis is important and improves the correlation of wing pressures with test data. Author

N89-19289*# Lockheed-Georgia Co., Marietta. Advanced Design Div.

MULTIPLE-PURPOSE SUBSONIC NAVAL AIRCRAFT (MPSNA) MULTIPLE APPLICATION PROPFAN STUDY (MAPS) Final Report

D. M. WINKELJOHN and C. H. MAYRAND Mar. 1986 88 p

(Contract NAS3-24528)

(NASA-CR-175096; NAS 1.26:175096; LG86ER0053) Avail: NTIS HC A05/MF A01 CSCL 01C

A conceptual design study compared a selected propfan-powered aircraft to a turbofan-powered aircraft for multiple Navy carrier-based support missions in the 1995 timeframe. Conventional takeoff and landing (CTOL) propfan and turbofan-powered designs and short takeoff/vertical landing (STOVL) propfan-powered designs are presented. Ten support mission profiles were defined and the aircraft were sized to be able to perform all ten missions. Emphasis was placed on efficient high altitude loiter for Airborne Early Warning (AEW) and low altitude high speed capability for various offensive and tactical support missions. The results of the study show that the propfan-powered designs have lighter gross weights, lower fuel fractions, and equal or greater performance capability than the turbofan-powered designs. Various sensitives were developed in the study, including the effect of using single-rotation versus counter-rotation propfans and the effect of AEW loiter altitude on vehicle gross weight and empty weight. A propfan technology development plan was presented which illustrates that the development of key components can be achieved without accelerated schedules through the extension of current and planned government and civil propfan programs. Author

N89-19290# Aeronautical Research Labs., Melbourne (Australia).

AN EXAMINATION OF THE FATIGUE METER RECORDS FROM THE RAAF (ROYAL AUSTRALIAN AIR FORCE) CARIBOU FLEET

DOUGLAS J. SHERMAN Jul. 1988 44 p

(AD-A201074; ARL/STRUC-TM-489; DODA-AR-005-526) Avail: NTIS HC A03/MF A01 CSCL 01C

In the early 1960's the Royal Australian Air Force ordered 25 Caribou I aircraft from the Canadian de Havilland Company. These aircraft came into service in 1964, and at the present time 21 of these aircraft are still on the register. The aircraft were all fitted with M1946 fatigue meters (Mk11), and these meters are, in general, read at the end of each flight. Since the beginning of March 1975 these fatigue meter data have been entered into a computer, and the present report is based on an analysis of the computerized data base extending from 3 March 1975 to 25 August 1984. This period includes data from just over 100 000 hours of flying - a very large data base- so the results have sufficient significance to distinguish between different gust load prediction methods. Of the various types of flying missions, type 4 (Display) is clearly more severe than all other types. At the two highest g levels, the loading frequencies are, respectively, 20 and 30 times the corresponding average frequencies for all types of flying. GRA

N89-19291# Naval Postgraduate School, Monterey, CA.

THE DESIGN AND INITIAL CONSTRUCTION OF A COMPOSITE RPV (REMOTELY PILOTED VEHICLE) FOR FLIGHT RESEARCH APPLICATIONS M.S. Thesis

H. KEITH PARKER Sep. 1988 100 p

(AD-A201884) Avail: NTIS HC A05/MF A01 CSCL 01C

A remotely piloted vehicle, similar to the U.S. Navy's Pioneer RPV, was designed and initial construction implemented for the purpose of establishing an RPV flight research program at the Naval Postgraduate School. The RPV will be used to investigate the Wortmann FX63-137 airfoil for low Reynolds applications, testing airborne avionic devices, investigate new aerodynamic phenomena of interest to NAVAIR, and serve as a transition trainer for future RPVs. Constructed primarily of composite materials, the vehicle will provide the opportunity to conduct real time/in-flight composite structural analysis. Additionally, the opportunity of using an RPV in their research, will provide the students of the Naval Postgraduate School with a unique capability limited to very few universities throughout the country. GRA

N89-19292# Naval Postgraduate School, Monterey, CA.
THE IMPORTANCE OF AIRCRAFT PERFORMANCE AND SIGNATURE REDUCTION UPON COMBAT SURVIVABILITY M.S. Thesis
JOHN D. LANGFORD, JR. Sep. 1988 128 p
(AD-A202106) Avail: NTIS HC A07/MF A01 CSCL 17D

An investigation was conducted to estimate the relative impact the six susceptibility reduction concepts of threat warning, tactics, signature reduction, noise jammers and deceivers, expendables, and threat suppression have on aircraft survivability, with particular emphasis given to tactics with increased aircraft performance and signature reduction. An essential elements analysis (EEA) was conducted for three representative scenarios, with and without threat warning available, to identify the essential events and elements in each scenario critical to aircraft survivability. The six concepts were assessed as to their relative impact on the essential events and an estimate of the aircraft's susceptibility and survivability was made. The results of the EEAs are presented in tabular format. The general conclusion is made that both increased aircraft performance, with threat warning available, and signature reduction, with and without threat warning available, play important roles in increasing aircraft survivability through a reduction in an aircraft's susceptibility. GRA

N89-19293# Air War Coll., Maxwell AFB, AL.
RPV (REMOTE PILOTED VEHICLE) APPLICATIONS IN THE US NAVY
MAXIMO A. BARELA and JAMES JACKSON May 1988 71 p
(AD-A202151; AU-AWC-88-052) Avail: NTIS HC A04/MF A01 CSCL 01C

This report describes the status of the U.S. Navy's remote piloted vehicle (RPV) program. It also presents numerous possible applications which exploit many of the RPV's capabilities. The author questions the aggressiveness and direction of the program and recommends that the program be modified so that it may fully exploit the RPVs' potentials. Appendices provide: (1) data on vehicle and payload capabilities of RPVs which are in current production or which are under development; and (2) a historical military perspective of the RPV from its birth to the present. GRA

N89-19294# Naval Postgraduate School, Monterey, CA.
A COMPARATIVE ANALYSIS OF TILT ROTOR AIRCRAFT VERSUS HELICOPTERS USING SIMULATOR RESULTS M.S. Thesis
GREGORY K. MISLICK Sep. 1988 74 p
(AD-A202190) Avail: NTIS HC A04/MF A01 CSCL 01C

This thesis conducts a comparative analysis of the tilt rotor aircraft with conventional helicopters using simulator results from LHX-representative missions. Results regarding inter-aircraft differences using Ordinary Least Squares regression analysis are discussed. Also examined are single versus dual piloted airframe configurations, cockpit designs, varied background inter-pilot differences, those transitions from the helicopter to the tilt rotor causing the most difficulties, those flight missions causing the most operator overloads, and what automated features best help relieve these workloads. Pilot opinions from a questionnaire concerning these subjects are also presented. Results show the tilt rotor superior in hard, maximum effort turns and in firing at elevated and depressed targets, while the helicopter has the advantage in lateral movements and quick hover up/hover down maneuvers. The two-man cockpit configuration is notably safer with significantly less operator overloads. Pilot differences between communities were found to be negligible in this study. GRA

N89-19295# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
COMBINED PRELIMINARY AIRWORTHINESS EVALUATION AND AIRWORTHINESS AND FLIGHT CHARACTERISTICS EVALUATION OF THE UH-1H WITH PREPRODUCTION HUB SPRING AND COMPOSITE MAIN ROTOR BLADES INSTALLED Final Report, 30 Jul. 1986 - 16 Nov. 1987
GARY L. SKINNER, JOSEPH PIOTROWSKI, MICHAEL E. WHITE, AUSTIN R. OMLIE, and JAMES D. BROWN Jun. 1988 53 p
(AD-A202316; USAAEFA-84-33) Avail: NTIS HC A04/MF A01 CSCL 01C

The Army has incorporated a main rotor hub spring on the UH-1H helicopter designed to reduce large main rotor flapping angles which occur during some flight maneuvers. Composite main rotor blades (CMRB), also incorporated, are intended to increase performance and to improve reliability and survivability of the UH-1H. A preliminary airworthiness evaluation was conducted to determine suitability of the combined preproduction CMRB and hub spring configuration for compliance with the CMRB Critical Item Development Specification (CIDS). Due to high vibration characteristics and the occurrence of cyclic control feedback contributing to loss of aircraft control associated with CMRB, additional testing was conducted for comparison with standard metal main rotor blades (STD) and composite main rotor blades constructed with production tooling (PROD CMRB). Flight testing was evaluated under a variety of operating conditions from field elevations of 2302 ft to 9980 ft. Some improvement was noted in out-of-ground effect hover performance with PROD CMRB compared to CMRB, while level flight performance of the CMRB and PROD CMRB was not significantly different. Performance improved for the PROD CMRB compared to STD, but did not meet CIDS requirements. GRA

N89-19297# Centre d'Essais Aeronautique Toulouse (France).
LIGHTNING CAMPAIGN 85/86 TRANSALL C160 A04: FLYING TESTS Final Report [CAMPAGNE FOUDRE 85/86 TRANSALL C160 A04. ESSAIS EN VOL. PROCES-VERBAL 85/535800]
ITEF M. ASSELINEAU 25 Apr. 1988 260 p In FRENCH
(REPT-85/535800; CR-010825; ETN-89-94096) Avail: NTIS HC A12/MF A01

The results of the lightning tests performed onboard a fully equipped aircraft are presented. A total of nine lightning discharges were observed. The data show maximum intensity of 10 kA, a maximum derivative of 100 kA/microsec, an average of 0.5 kA/microsec, and a maximum duration of 320 ms. ESA

N89-19859*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
CHEMICAL WARFARE PROTECTION FOR THE COCKPIT OF FUTURE AIRCRAFT
WILLIAM C. PICKL *In* NASA. Lyndon B. Johnson Space Center, 2nd Annual Workshop on Space Operations Automation and Robotics (SOAR 1988) p 309-312 Nov. 1988
Avail: NTIS HC A22/MF A01 CSCL 01C

Currently systems are being developed which will filter chemical and biological contaminants from crew station air. In order to maximize the benefits of these systems, a method of keeping the cockpit contaminant free during pilot ingress and egress is needed. One solution is to use a rectangular plastic curtain to seal the four edges of the canopy frame to the canopy sill. The curtain is stored in a tray which is recessed into the canopy sill and unfolds in accordion fashion as the canopy is raised. A two way zipper developed by Calspan could be used as an airlock between the pilot's oversuit and the cockpit. This system eliminates the pilot's need for heavy and restrictive CB gear because he would never be exposed to the chemical warfare environment. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A89-29428
AIRBORNE MTI VIA DIGITAL FILTERING
J. ENDER and R. KLEMM (Forschungsgesellschaft fuer angewandte Naturwissenschaften, Forschungsinstitut fuer Funk und Mathematik, Wachtberg-Werthhoven, Federal Republic of Germany) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0143-7070), vol. 136, pt. F, no. 1, Feb. 1989, p. 22-28. refs

A simple clutter suppression technique for airborne moving target indicators (MTIs) is proposed which exploits the special properties of a linear equispaced array antenna aligned in the flight direction. In the present method, equidistant pulses are transmitted, and the temporal and spatial samples are equivalent. The method is found to provide better target detection than airborne MTI techniques based on oversampling. It is suggested that the inverse clutter filter can be employed as an output for SAR imaging with improved SNR. R.R.

A89-29455
MDHC'S ENHANCED DIAGNOSTIC SYSTEM, A UNIQUE AND COMPREHENSIVE APPROACH TO STRUCTURAL MONITORING
JAMES HARRINGTON, III, DAVID CHIA (McDonnell Douglas Helicopter Co., Mesa, AZ), and JAMES NEFF IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. Research supported by the U.S. Army. refs

Currently in the helicopter industry, structural component lives and inspection criteria are established by damage tolerance or safe life methods. An accurate determination of the loading spectrum of the component is required for both methodologies. Structural monitoring of aircraft through the use of flight data recorder technology could substantially reduce the uncertainties in the load spectrum used in component life analysis. McDonnell Douglas Helicopter Company has developed a multi-functional flight data recorder system for the Army's AH-64A Apache Helicopter. One of the primary functions of the Enhanced Diagnostic System (EDS) is to obtain operational loads data. EDS structural monitoring is unique because it uses aircraft mission subsystems data as well as strain gage data to monitor loads and aircraft usage. The purpose of this paper is to describe the EDS structural monitoring approach and to propose a methodology for using the EDS structural loads data in a comprehensive Structural Integrity Program. Author

A89-30966* Atmospheric Science Associates, Concord, MA.
THREE-DIMENSIONAL TRAJECTORY ANALYSES OF TWO DROP SIZING INSTRUMENTS - PMS OAP AND PMS FSSP
HILLYER G. NORMENT (Atmospheric Science Associates, Concord, MA) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 5, Dec. 1988, p. 743-756. Research supported by NASA. Previously announced in STAR as N88-18574. refs

Flow induced distortions of water drop fluxes and speeds seen by the instruments were predicted by use of three dimensional flow and trajectory calculation methods. Sensitivities were determined for the instruments, in isolation and mounted under the wing of an airplane, to: water drop diameter (2 to 1000 microns), angle of attack and free stream air speed. For the optical array probe in isolation and on the airplane at 0 deg angle of attack, flux distortions of practical consequence are not found. At 4 deg airplane angle of attack, partial flow stagnation under the uptilted wing causes significant decreases in both flux and speed for cloud size droplets. For the forward scattering spectrometer probe in isolation, only marginally significant sensitivities to free stream air speed are found, and no sensitivity is found to angle of attack. Both speed and flux of cloud size droplets are predicted to be undermeasured by from 12 to 24 percent depending on airplane angle of attack. For the wing-mounted instruments, effects of flow about the instruments themselves are found to be equal in importance to effects of flow about the airplane. Preferred orientation (canting) angles of distorted water drops are found to be functions of drop size, angle of attack and air speed.

A89-30987
COMPACT DIAGNOSTIC CO-PROCESSORS FOR AVIONIC USE
R. M. STEWART and C. S. SULLEY (Stewart Hughes, Ltd., Southampton, England) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 189-199.

Monitoring systems for helicopters have hitherto been limited to simple level checking of such parameters as vibration, metallic debris, and turbine exit temperature. Recent advances in both monitoring and diagnostic techniques have, however, opened up a whole range of possibilities for reducing the operating costs of helicopters, and the search is now on for the processing units able to implement these advances. The author describes one solution to the processing problem that involves use of a new computing device known as the transputer. Reductions in volume of 10:1 are achievable using it, and the solution has many other attractive attributes including reduced software writing costs and greater flexibility. Author

A89-30992
DEVELOPMENT OF AN ONBOARD MAINTENANCE COMPUTER FOR THE AH-64
KEITH N. PIERCE (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 262-270.

The application of microprocessor and digital data bus technology to on-board automated maintenance diagnostics is described. The goal is to improve the supportability of the Apache by reducing false removals and troubleshooting time, and by lowering the maintenance skill levels and the number of specialties required to support the aircraft. An automated maintenance aid is being developed to record and analyze data transmitted on the MIL-STD-1553A multiplex bus. In effect, it will be possible to identify faults and isolate them into the line replaceable unit or module level. K.K.

A89-31004
ADVANCED INSTRUMENTATION FOR ADVANCED AIRCRAFT
DAVID PENHARLOW (Aydin Corp., Vector Div., Newtown, PA) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 49-56.

Novel distributed data-acquisition system designs allow flight test instrumentation engineers to select hardware with reduced volume and weight that requires minimal wiring among components while yielding improved accuracy and resolution. Data conditioning and encoding can be achieved near the sensors through a variety of remote units; the remote units for these applications differ with measurement type and test-program requirements. Attention is given to the illustrative cases of (1) a solid rocket booster motor; (2) a European advanced fighter aircraft; (3) a tilt-rotor aircraft; (4) an advanced tactical fighter; (5) a flying engine test-bed; and (6) several experimental commercial aircraft. O.C.

A89-31019
A SYSTEM CONFORMING TO THE NEW IRIG STANDARD FOR PROCESSING MIL-STD-1553 DATA
DAVID PAYNE and MIKE O'BRIEN (Fairchild Weston Systems,

Inc., Sarasota, FL) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 267-274.

In the 1990s, aircraft development programs will employ multiple MIL-STD-1553 data busses to furnish avionics subsystems control, as proposed in chapter 8 of the IRIG-106 document. Each such airborne system must, among other things, acquire all messages from up to eight separate MIL-STD-1553 data busses, and encode all information into a standard PCM code to allow utilization of existing IRIG airborne tape recorders; ground processing equipment must employ such existing IRIG PCM ground equipment as frame synchronizers, preprocessors, and data bases. Attention is given to the EMR 5500 All Bus Instrumentation System. O.C.

A89-31021

A HIGH DATA RATE AIRBORNE ROTARY RECORDER WITH LONG RECORD TIME

VICTOR LEUNG (DATATAPE, Inc., Pasadena, CA) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 317-324.

Application of instrumentation recorders for data acquisition in hostile environments has for years been accomplished by means of longitudinal recorders specially designed for that application. DATATAPE Incorporated has been the leader in providing such recorders beginning with its MARS series. Two recent trends have impacted the applicability of these machines: the need for record times longer than can be provided by the longitudinal machines and the trend in the instrumentation industry to utilize digital recording techniques. Author

A89-31059

THE IPTN'S AIRBORNE DATA RELAY SYSTEM (ADRES) - A SYSTEM CONCEPT AND THE PHASE ONE SYSTEM CONFIGURATION

ADI DHARMA SOELAIMAN and FAUZI EFFENDY ROESMA (Indonesian Aircraft Industry, Ltd., Bandung, Indonesia) IN: ITC/USA/'88; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 17-20, 1988. Research Triangle Park, NC, Instrument Society of America, 1988, p. 729-738.

By making use of NC212-200 commuter aircraft as an airborne container, the airborne data relay system (ADRS), had been configured and tested in an experimental status during the year of 1987. A kind of test on EMC, EMI, RFI, and telemetry data link were applied to the system. Prior to the IPTN's flight test program in the year of 1988-1992, the ADRS is designed not only to receive and to relay the data, but also planned to be able to process the data for quick data analysis purposes on board. This paper describes the ADRS system concept and its experimental status system, the Phase One system configuration. Author

A89-31611

A COMPARISON OF A STEREOSCOPIC 3-D DISPLAY VERSUS A 2-D DISPLAY USING ADVANCED AIR-TO-AIR FORMAT

JOHN ZENYUH, JOHN M. REISING, SCOTT WALCHLI (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and DAVID BIERS (Dayton, University, OH) IN: Human Factors Society, Annual Meeting, 32nd, Anaheim, CA, Oct. 24-28, 1988, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1988, p. 53-57. refs

A stereoscopic three-dimensional display and a conventional two-dimensional display are compared, focusing on the ability to provide spatial location information in the context of an air-to-air fighter mission. Simulation tests were conducted to evaluate a subject's response speed and accuracy in a search task and to measure deviations from the given track on the flight task. It is found that those formats presented with the stereoscopic three-dimensional display resulted in greater accuracy. R.B.

N89-18446# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.

SOFTWARE ENGINEERING AND ITS APPLICATION TO AVIONICS

Nov. 1988 405 p In ENGLISH and FRENCH Symposium held in Cesme, Turkey, 25-29 Apr. 1988
(AGARD-CP-439; ISBN-92-835-0483-6; AD-A203892) Avail: NTIS HC A18/MF A01

Software engineering has evolved rapidly but the gap between demand and software output continues to grow. By the end of the decade research programs in North America, Europe, and Japan will begin to produce results in the areas such as software tools, and computer architecture. The symposium considered how their advances might be applied to the avionics systems of the nineties and beyond and their impact on the aspirations in areas such as operation, and fault tolerances. The software element of modern weapons systems continues to grow in size and complexity; offering major advantages but also potential risks.

N89-18447# Test Wing (6510th), Edwards AFB, CA. F-16 Combined Test Force.

MEASURES OF MERIT FOR ADVANCED MILITARY AVIONICS: A USER'S PERSPECTIVE ON SOFTWARE UTILITY

MARK C. DICKERSON and VICTOR M. LASAXON (Computer Sciences Corp., Edwards AFB, CA.) *In* AGARD, Software Engineering and Its Application to Avionics 14 p Nov. 1988
Avail: NTIS HC A18/MF A01

Recommendations are provided for improving the software development process. The recommendations are the result of discussions with F-15, F-16, and HH-60 test pilots, navigators, and flight test engineers. Because today's aircraft are becoming so software intensive, and because the development process is so involved, users and developers must redouble efforts to design systems correctly for the first time. Although 29 specific recommendations are given, they can be boiled down to four general guidelines: keep switch actions to a minimum; keep switchology consistent; tailor displays by flight phase, but keep other options visible; tailor displays by flight phase, but keep other options visible; and most important, carefully process and meter the information presented to avoid pilot overload. Author

N89-18448# French Air Force, Paris. Div. Nouveaux Avions de Combat.

RESPONSIBLE REQUIREMENTS DEFINITION FOR COMBAT AIRCRAFT IN LIGHT OF UNCERTAINTIES LINKED TO ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS TECHNIQUES [LE RESPONSABLE DE L'EXPRESSION DU BESOIN FACE AUX INCERTITUDES LIEES AUX TECHNIQUES DE L'INTELLIGENCE ARTIFICIELLE ET DES SYSTEMS EXPERTS SUR LES AVIONS DE COMBAT]

JEAN-GEORGES BREVOT *In* AGARD, Software Engineering and Its Application to Avionics 8 p Nov. 1988 In FRENCH
Avail: NTIS HC A18/MF A01

The factors involved in the definition of requirements for combat aircraft are discussed with particular attention being given to the development of operational specifications, prediction of future combat mission conditions, technology advances, cost and development problems, and crew workloads. The application domains of artificial intelligence and expert systems are outlined and the advantages and disadvantages of the systems are discussed. Author

N89-18452# Aerospatiale, Marignane (France). Div. Helicopteres.

CONTROL OF ON-BOARD SOFTWARE [MAITRISE DES LOGICIELS EMBARQUES]

MONIQUE SLISSA and PIERRE VILLEDIEU *In* AGARD, Software Engineering and Its Application to Avionics 10 p Nov. 1988 In FRENCH
Avail: NTIS HC A18/MF A01

Various aspects of the flight software development process are examined including the evolution of the industrial environment, the general strategy for system management, and the politics of software development. Productivity concepts such as code reusability and error minimization are addressed. Specific attention is given to the software development cycle and methodologies utilized by the Aerospatiale Helicopter Division. Author

N89-18454# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
AVIONICS SYSTEMS ENGINEERING AND ITS RELATIONSHIP TO MISSION SOFTWARE DEVELOPMENT
HERBERT KLENK and HELMUT RAPP *In* AGARD, Software Engineering and Its Application to Avionics 13 p Nov. 1988
Avail: NTIS HC A18/MF A01

The introduction of digital avionics into military fighter aircraft and the accompanying transition from electromechanical to software-intensive systems are forcing the aviation industry into new approaches to systems design, development, integration, and test. The avionic systems development and methodology established and used at MBB, its relationship to software development and the experiences made by the application of this development methodology and its related tools to such major programs as the development of the Electronic Combat Reconnaissance Tornado, the integration of the HARM missile into the Interdiction Strike Tornado and the Improved Combat Efficiency Program of the German F-4F Phantom. As far as the weapon system Tornado is concerned, avionics system design, integration, and test as well as system software are trinational under takings which include three different customers and different operational needs. Any systems development methodology has to reflect these prerequisites. Therefore, also addressed are the problems and solutions for international cooperation in systems and software development and their impact upon project management and control. The toolset in use for system development requires further enhancements. Potential improvements of existing and requirements for additional tools are also being described. Author

N89-18469# Allgeimeine Elektrizitaets-Gesellschaft, Ulm (Germany, F.R.). Airborne Radar System Group.
AVIONICS EXPERT SYSTEMS
ULRICH D. HOLZBAUR *In* AGARD, Software Engineering and Its Application to Avionics 18 p Nov. 1988
Avail: NTIS HC A18/MF A01

Some experiences and ideas on the expert systems (XS) approach to solving problems of avionic data processing are presented. The focus is on problems concerning fighter aircraft and within these mainly on radar components. Avionics expert systems may be a development tool, part of a ground support system or integrated in an avionics data processing system. In the aircraft, main applications comprise mission oriented tasks like pilot's associate and sensor oriented tasts like navigation or radar. Areas in which more intelligent radar data processing is needed comprise situation awareness, mode selection, and electronic counter countermeasures (ECCM), noncooperative target identification (NCI), and radiation management. To show the applicability of the expert systems approach to identification tasks, a demonstration system for the recognition of aircraft from the textural description of a picture was developed and tested. Author

N89-18471# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
INTEGRATION OF VOCAL DIALOGUE ON-BOARD A COMBAT AIRCRAFT [INTEGRATION DU DIALOGUE VOCAL A BORD D'UN AVION DE COMBAT]
J. L. BUSTAMANTE *In* AGARD, Software Engineering and Its Application to Avionics 10 p Nov. 1988 In FRENCH
Avail: NTIS HC A18/MF A01

The integration and use of vocal dialogue methods in combat aircraft is examined. In particular, research related to the simulation and implementation of such methods on the Rafale demonstrator aircraft is described. Integration of voice command capabilities with head-up and other visual displays is addressed. A tapping rhythm task was performed to assess pilot performance with and without voice dialogue. Author

N89-18472# General Dynamics Corp., Fort Worth, TX.
INTEGRATION OF ADVANCED SAFETY ENHANCEMENTS FOR F-16 TERRAIN FOLLOWING
JAMES BLAYLOCK, DONALD SWIHART, and WILLIAM URSCHEL (Aeronautical Systems Div., Wright-Patterson AFB, OH.) *In* AGARD, Software Engineering and Its Application to Avionics 10 p Nov. 1988 Previously announced as A88-22573
Avail: NTIS HC A18/MF A01

Application of System-Wide Integrity Management (SWIM) to the maximization of flight safety for the F-16 terrain following (TF) system is considered. The architecture of the F-16 TF system is discussed, identifying areas where conventional self-test is not sufficient to ensure flight safety. Detection of flight-critical malfunctions by SWIM is followed by an automatic recovery maneuver consisting of a roll to wings-level fly-up for the F-16 system. The addition of SWIM to the single-thread configuration of the F-16 TF system results in 14 percent predicted mishap rate reduction at far less cost and installation impact than the redundant configuration (which offers a 17 percent reduction). Author

N89-18486# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft Div.
ADA IN EMBEDDED AVIONIC SYSTEMS
W. MANSEL *In* AGARD, Software Engineering and Its Application to Avionics 7 p Nov. 1988
Avail: NTIS HC A18/MF A01

Ada will be used for real-time avionic software on the Tornado aircraft upgrade program and on the EFA program. For the HARM integration program onto the Tornade aircraft an Ada crosscompiler based on the Karlsruhe compiler technology configured to a multiprocessor avionic computer is used. Software prototyping was applied to gain experience with Ada avionics application. The results will be discussed as well as the experience from benchmark tests on different Ada crosscompiler systems for the single processor MC 68000 and 68020 microprocessor targets. Special emphasis will be taken on Ada tasking and the parallelism in avionic software. Author

N89-19298# Naval Air Test Center, Patuxent River, MD.
DEVELOPMENT OF A LOW-COST HELMET MOUNTED EYE GAZE SENSOR
RICHARD S. DUNN and DONNA L. HASPEL 27 Oct. 1988 33 p
(AD-A202303; NATC-TM-88-46-SY) Avail: NTIS HC A03/MF A01 CSCL 06D

This report documents Phase 1 of a Small Business Innovation Research (SBIR) contract for development of a low-cost helmet mounted eye gaze point sensor. The device, in completed form, is for use in laboratory, simulator, and in-flight studies by NAVAIRTESTCEN in aircraft test and evaluation projects. Numerous other potential applications in behavioral research and development would benefit from use of the device throughout the Department of Defense and in commercial and academic settings. The device produces a time history of eye gaze point information along with pupil diameter and eye-blink data. It has flexibility as a sensor system for many different modes of application. Sentient Systems Technology, Incorporated, completed design, testing, prototype hardware and software development, and functional testing of a prototype unit. The effort constituted a full feasibility demonstration in the multistage SBIR contract cycle format. Success in Phase 1 is intended to lead to follow-on contracts for engineering development and applications development or production during Phases 2 and 3. Functional demonstrations of the prototype unit with Sun Microsystems computer equipment were convincing and fully successful. A complete prototype with simplified software for operation with an IBM compatible PC system is now being evaluated for in-house applications in a behavioral test and evaluation laboratory setting. GRA

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A89-29323

TURBINE TECHNOLOGY - MATERIALS SET THE SPACE (FIFTH CLIFF GARRETT TURBOMACHINERY AWARD LECTURE, ANAHEIM, CA, OCT. 3, 1988)

F. BLAKE WALLACE (General Motors ,Corp., Allison Gas Turbine Div., Indianapolis, IN) Warrendale, PA, Society of Automotive Engineers, Inc., 1988, 15 p.

(SAE SP-764)

A development history of aircraft gas turbine engines is presented which proceeds from the viewpoint of gradual performance gains' fundamental dependence on the identification and economical production of higher-temperature/lower-density compressor and turbine materials. An attempt is made to clarify comparative gains over the course of several technological generations since the Whittle and von Ohain gas turbines of the 1930s, and to project prospective gains in specific power that may follow the development of suitable ceramic and metal-matrix composite materials in the near future. O.C.

A89-29441

PROPULSION SYSTEMS FOR HYPERSONIC VEHICLES

Aerospace Engineering (ISSN 0736-2536), vol. 9, Feb. 1989, p. 9-12.

Effective propulsion systems for vehicles cruising at speeds in excess of Mach 5 will be required to sustain supersonic flow within the engine; the resulting lower temperatures will allow internal forces and heat fluxes to be kept at moderate levels, and permit a more substantial addition of heat by fuel combustion without incurring thermodynamic losses due to molecular dissociation. An account is presently given of advanced-cycle powerplants currently being considered for hypersonic aircraft; these encompass such configurations as the convertible turbofan/ramjet, the combined-nacelle turbojet/ramjet, the turbine-bypass ramjet engine, the supersonic throughflow turbofan, the air turboramjet, the gas generator/air turboramjet, the twin-spool hydrogen expander, the gas generator/air turboramjet with precooler, the dual-combustion ramjet, and the oblique-detonation wave test engine. O.C.

A89-30647#

CONCEPT OF A MODEL FOR CALCULATING THE DURABILITY OF GAS TURBINE ENGINE BLADES [KONCEPCJA MODELU OBLICZENIOWEGO TRWALOSCI LOPATEK TURBIN SILNIKOW ODRZUTOWYCH]

TADEUSZ KACZYNSKI (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, July 1988, p. 8-10. In Polish. refs

The variable loading of gas turbine engine blades is examined. Attention is given to three models commonly used for calculating the durability of blades, derived from dislocation, energy, and statistical approaches. An original model for calculating blade durability is also proposed. B.J.

A89-30745*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPUTATIONAL STRUCTURAL MECHANICS FOR ENGINE STRUCTURES

CHRISTOS C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 868-873. Previously announced in STAR as N88-22399.

(AIAA PAPER 89-1260)

The computational structural mechanics (CSM) program at Lewis encompasses the formulation and solution of structural mechanics problems and the development of integrated software systems to computationally simulate the performance, durability, and life of engine structures. It is structured to supplement, complement, and, whenever possible, replace costly experimental efforts. Specific objectives are to investigate unique advantages of parallel and multiprocessing for reformulating and solving structural mechanics and formulating and solving multidisciplinary mechanics and to develop integrated structural system computational simulators for predicting structural performance, evaluating newly developed methods, and identifying and prioritizing improved or missing methods. Author

A89-30860#

AERODYNAMICALLY FORCED RESPONSE AND FLUTTER OF STRUCTURALLY MISTUNED BLADED DISKS IN SUBSONIC FLOW

GREGORY H. HENDERSON and SANFORD FLEETER (Purdue University, West Lafayette, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1991-1999. refs

(AIAA PAPER 89-1387)

To analyze the aeroelastic characteristics of structurally mistuned rotors, both flutter and forced response, a structural dynamics model appropriate for flexible bladed disks is developed utilizing flexible disk theory and small perturbation gust and motion-induced unsteady aerodynamic analyses. This model is then used to investigate the effects of structural mistuning on rotor aeroelasticity. Mistuning is found to be beneficial for flutter stability, with the motion-induced unsteady aerodynamics and thus the stability somewhat dependent on the far field acoustic wave behavior generated by the blade motion, as indicated by the acoustic resonance conditions. With regard to forced response, mistuning is shown to be generally detrimental. Author

A89-30986

RUB IN HIGH PERFORMANCE TURBOMACHINERY. II - SPECTRAL ANALYSIS AND PATTERN RECOGNITION

JOE PADOVAN, FRED K. CHOY, and W. H. LI (Akron, University, OH) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 169-177.

An overall signature analysis methodology is established to enable pattern recognition for rub interaction problems in rotating equipment. Attention is given to the analysis of the onset and steady-state phases of rub events. An attempt is made to determine the most likely sites for locating sensors/transducers so as to properly define rub events and their associated severity levels. K.K.

A89-31803#

NUMERICAL SIMULATION OF UNSTEADY COMBUSTION IN A DUMP COMBUSTOR [SIMULATION NUMERIQUE DU FONCTIONNEMENT INSTATIONNAIRE D'UN FOYER A ELARGISSEMENT BRUSQUE]

F. GARNIER, B. LABEGORRE, M. SERRANO, and A. LA VERDANT (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Specialists' Meeting on Combustion Instabilities in Liquid-Fuelled Propulsion Systems, 72nd, Bath, England, Oct. 3-7, 1988) ONERA, TP, no. 1988-142, 1988, 21 p. In French. Research supported by DRET and ONERA. refs

(ONERA, TP NO. 1988-142)

A computer code for the study of diesel engines has been modified by the introduction of limiting conditions for inflow and outflow in order to study a ramjet dump combustor with liquid fuel injection. Utilization of a zero-slope technique is found to overcome difficulties encountered with the method of characteristics for the case of reactive two-phase three-dimensional flow. The method is shown to realistically simulate the physical-chemical mechanisms involved, along with the hydrodynamic characteristics of the flow. R.R.

A89-31805#
THE CONTRIBUTION OF WIND TUNNEL TESTS TO THE UNDERSTANDING OF COMPRESSOR BLADE FLUTTER [LE FLOTTEMENT DES AUBES DE COMPRESSEUR - UNE CERTAINE COMPREHENSION GRACE A DES ESSAIS EN SOUFFLERIE]
E. SZECHENYI and I. CAFARELLI (ONERA, Chatillon-sous-Bagneux, France) (SFM, Journees d'Etude, Paris, France, Oct. 12, 13, 1988) ONERA, TP, no. 1988-144, 1988, 27 p. In French. refs
(ONERA, TP NO. 1988-144)
Experimental results were obtained in a straight cascade wind tunnel in order to study the physical causes of various types of flutter experienced by turbojet compressor blades. It is found that flutter is influenced by both the coupling coefficients and the direct coefficients, particularly for the case of adjacent blades, and that flutter is not exclusively an effect due to the cascade. It is noted that the effect of interblade coupling depends largely on the blade frequency tuning. R.R.

N89-18488# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
DEVELOPING CRITERIA FOR SAMPLE SIZES IN JET ENGINE ANALYTICAL COMPONENT INSPECTIONS AND THE ASSOCIATED CONFIDENCE LEVELS M.S. Thesis
TAMI S. RICHARDS Sep. 1988 131 p
(AD-A201508; AFIT/GSM/LSM/88S-22) Avail: NTIS HC A07/MF A01 CSCL 21E
This thesis provides managers of USAF jet engine programs with a model to help determine an appropriate sample size of engines/components to be inspected in a Lead-the-Force/Analytical Component Inspection (LTF/ACI) program. The major purpose of such a program is to identify problems and failure trends in engines/components before the problems are experienced by the majority of the fleet, based on the concept that a sample of engines with accelerated operating hours can represent the future status of the entire fleet. Initial engine/component inspection intervals for the fleet are set low and extended as LTF/ACI engines/components pass inspection criteria. Specific objectives are: (1) to determine what sample size of components is required to reach some specific level of confidence that the inspection intervals for the fleet can be increased, (i.e., the fleet can continue flying past that initial interval safely); and (2) to determine the risk or decrease in confidence associated with a less-than-optimum sample size. Small sample binomial statistics were used for the analysis due to the small number of engines/components usually inspected in an LTF/ACI program and the pass/fail nature of the inspection plan. The study found that the increase (decrease) in confidence attained by varying the sample size of engines/components slightly is significant enough to warrant careful consideration by managers attempting to balance cost, logistical, and engineering constraints. GRA

N89-18489# Rolls-Royce Ltd., Derby (England). Product Strategy Dept.
ENGINE DEVELOPMENTS
J. M. ROBERTSON 15 Mar. 1988 18 p Presented at the 1988 Aviation Conference on Airline Insurance - What Next?, London, England, 15-16 Mar. 1988
(PNR90474; ETN-89-93676) Avail: NTIS HC A03/MF A01
The trends of engine development are discussed and forecasts of the market showing the importance of the big fan engine are presented. The technology changes that are heralding different configurations of engine are commented. The economic justification for launching propfan engines is not yet apparent. The greater value part of the future civil aeroengine market is in big fan engines. ESA

N89-18491# Rolls-Royce Ltd., Derby (England). Theoretical Science Group.
STRUCTURAL LOADS DUE TO SURGE IN AN AXIAL COMPRESSOR
N. T. BIRCH, J. B. BROWNELL, A. M. CARGILL, M. R. LAWSON, R. J. PARKER, and K. G. TILLEN 9 May 1988 15 p Presented at the 4th International Conference on Vibration in Rotating Machines, Edinburgh, Scotland, 13-15 Sep. 1988
(PNR90493; ETN-89-93688) Avail: NTIS HC A03/MF A01
A model for predicting the large impulsive loads that occur during surge in an axial flow compressor is described. The model combines a computational fluid dynamics method for the unsteady aerodynamic blade-shock tube experiment, which involves laser methods of flow visualization, and measurements of blade deflection using strain gages and Moire photography. The results are shown to be in good agreement with the computations, confirming the validity of the method. ESA

N89-18492# Rolls-Royce Ltd., Bristol (England). Engine Data Systems Dept.
MILITARY ENGINE CONDITION MONITORING SYSTEMS: THE UK EXPERIENCE
C. M. OCONNER 30 May 1988 8 p Presented at the AGARD PEP 71st Symposium on Condition Monitoring, Quebec, 30 May - 3 Jun. 1988 Sponsored by the Ministry of Defence Procurement Executive, London, England
(PNR90512; ETN-89-93695) Avail: NTIS HC A02/MF A01
Monitoring systems are described including a low cycle fatigue and creep turboengine testing system, a turbine creep checking gage, the Pegasus engine life recorder, a special engine use monitoring system (adaptable to engine type), and a microprocessor controlled life use counter fitted to several military aircraft types on a limited basis. The standard engine monitoring system adopted for Harrier GR5 aircraft is detailed. ESA

N89-18494# Rolls-Royce Ltd., Derby (England). Theoretical Science Group.
CFD APPLICATIONS TO THE AERO-THERMODYNAMICS OF TURBOMACHINERY
P. STOW 22 Jun. 1988 41 p Presented at the ICFD Conference on Numerical Methods for Fluid Dynamics, Oxford, England, 21-24 Mar. 1988 Submitted for publication
(PNR90520; ETN-89-93697) Avail: NTIS HC A03/MF A01
The application of computational fluid dynamics to a number of areas is described. The trends for further development of the numerical and mathematical models are discussed, including multigrid methods, accuracy of algorithms, robustness of solvers, boundary conditions, and grid systems. It is clear that in order to extend the impact of computational fluid dynamics there are a number of improvements to make both in quality and cost of the solutions. ESA

N89-18495# Rolls-Royce Ltd., Derby (England).
THE FORMAL VERIFICATION OF SAFETY-CRITICAL ASSEMBLY CODE
IAN M. ONEILL, DENTON L. CLUTTERBUCK, PAUL F. FARROW (Lucas Aerospace Ltd., Birmingham, England), PETER G. SUMMERS, and WILLIAM C. DOLMAN 9 Nov. 1988 7 p Presented at the Safecomp '88, Fulda, Fed. Republic of Germany, 9-11 Nov. 1988
(PNR90524; ETN-89-93699) Avail: NTIS HC A02/MF A01
The use of the SPADE static analysis and verification tools to model, analyze, and formally verify the LUCOL assembly code modules used in the fuel control unit of the RB211-524G jet engine is described. The construction of a rigorous model of Z8002 assembly code amenable to analysis and formal verification by SPADE; the rapid development in Prolog of a translator from Z8002 assembly code to FDL (SPADE's modelling language); the formalization of the written specifications provided into pre- and post-conditions expressed in first-order predicate calculus; and the use of the SPADE Proof Checker to carry out the proofs of correctness are mentioned. ESA

N89-18496# Rolls-Royce Ltd., Derby (England).
REQUIREMENTS IN THE DEVELOPMENT OF GAS TURBINE COMBUSTORS
B. JONES 14 Sep. 1987 14 p Presented at the NATO/Advanced Study Institute Conference on Instrumentation for Combustion and Flow in Engines, Vimeiro, Portugal, 14-25 Sep. 1987
(PNR90528; ETN-89-93700) Avail: NTIS HC A03/MF A01

Aspects of combustor design, including the combustion process; aerodynamics; emissions; cooling; fuel injection; and combustion stability are summarized. The combustor of a modern, large gas turbine accounts for 1 pct of the engine weight and cost. Emission regulations result in the achievement of a combustion efficiency of near 100 pct at all operating conditions. The only way therefore, in which improvement to the combustor can contribute significantly to the performance of the engine is through a reduction in parasitic pressure loss, a reduction in length, an increase in component life, or in improved outlet temperature distribution. ESA

N89-19262*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBOMACHINERY AEROELASTICITY AT NASA LEWIS RESEARCH CENTER
KRISHNA RAO V. KAZA *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 571-603 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 21E

The turbomachinery aeroelastic effort is focused on unstalled and stalled flutter, forced response, and whirl flutter of both single rotation and counter rotation propfans. It also includes forced response of the Space Shuttle Main Engine (SSME) turbopump blades. Because of certain unique features of propfans and the SSME turbopump blades, it is not possible to directly use the existing aeroelastic technology of conventional propellers, turbofans or helicopters. Therefore, reliable aeroelastic stability and response analysis methods for these propulsion systems must be developed. The development of these methods for propfans requires specific basic technology disciplines, such as 2-D and 3-D steady and unsteady aerodynamic theories in subsonic, transonic and supersonic flow regimes; modeling of composite blades; geometric nonlinear effects; and passive and active control of flutter and response. These methods are incorporated in a computer program, ASTROP. The program has flexibility such that new and future models in basic disciplines can be easily implemented. Author

N89-19263*# United Technologies Research Center, East Hartford, CT.
UNSTEADY AERODYNAMICS OF BLADE ROWS
JOSEPH M. VERDON *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 2 p 605-630 Feb. 1989
Avail: NTIS HC A17/MF A01 CSCL 21E

The requirements placed on an unsteady aerodynamic theory intended for turbomachinery aeroelastic or aeroacoustic applications are discussed along with a brief description of the various theoretical models that are available to address these requirements. The major emphasis is placed on the description of a linearized inviscid theory which fully accounts for the affects of a nonuniform mean or steady flow on unsteady aerodynamic response. Although this linearization was developed primarily for blade flutter prediction, more general equations are presented which account for unsteady excitations due to incident external aerodynamic disturbances as well as those due to prescribed blade motions. The motivation for this linearized unsteady aerodynamic theory is focused on, its physical and mathematical formulation is outlined and examples are presented to illustrate the status of numerical solution procedures and several effects of mean flow nonuniformity on unsteady aerodynamic response. Author

N89-19299*# Hamilton Standard Div., United Aircraft Corp., Windsor Locks, CT.
LARGE-SCALE ADVANCED PROP-FAN (LAP) HUB/BLADE RETENTION DESIGN REPORT
MATTHEW SOULE 31 Jan. 1986 77 p
(Contract NAS3-23051)
(NASA-CR-174786; NAS 1.26:174786; HSER-9247) Avail: NTIS HC A05/MF A01 CSCL 21E

The Large-scale Advanced Prop-fan (LAP) hub assembly forms a semi-rigid link between the blades, which provide the thrust, and the engine shaft, which provides the torque. The hub and tailshaft is a one piece partially forged part which is carburized, heat treated and machined. A single row ball bearing restrains each of the eight blades in the hub, while the tailshaft secures the propeller to the engine shaft with two cone seats that are preloaded against each other by the Prop-fan retaining nut. The hub also forms the support for the pitch change actuator system, the control and the spinner. The retention transmits the loads from the blades to the hub while allowing the changes in blade pitch. The single row ball bearing retention provides ease of maintenance by allowing individual blade replacement without dissassembly of the hub. It has a through hardened inner race which seats against the aluminum blade shank and an outer race which is integral with the barrel. The outer race area is carburized to achieve the hardness necessary to support the ball loads. The balls are kept from contact with each other by a separator. The rotational speed of the propeller keeps the retention submerged in the oil which is contained in the hub by a seal. Stress and strain analysis, material hardness requirements, weight predictions, and stiffness characteristics are discussed. Author

N89-19300*# Douglas Aircraft Co., Inc., Long Beach, CA.
MULTIPLE APPLICATION PROPFAN STUDY (MAPS): ADVANCED TACTICAL TRANSPORT Final Report, Aug. 1984 - Apr. 1985
F. C. NEWTON, R. H. LIEBECK, G. H. MITCHELL, A. MOOIWEER, M. M. PLATTE, T. L. TOOGOOD, and R. A. WRIGHT Mar. 1986 105 p
(Contract NAS3-24348)
(NASA-CR-175003; NAS 1.26:175003) Avail: NTIS HC A06/MF A01 CSCL 21E

This study was conducted to ascertain potential benefits of a propfan propulsion system application to a blended wing/body military tactical transport. Based on a design cruise Mach no. of 0.75 for the design mission, the results indicate a significant advantage in various figures of merit for the propfan over those of a comparable technology turbofan. Although the propfan has a 1.6 percent greater takeoff gross weight, its life cycle cost is 5.3 percent smaller, partly because of a 27 percent smaller specific fuel consumption. When employed on alternate missions, the propfan configuration offers significantly improved flexibility and capability: an increase in sea level penetration distance of more than 100 percent, or in time-on-station of 24 percent, or in deployment payload of 38 percent. Author

N89-19301# Detroit Diesel Allison, Indianapolis, IN. Allison Gas Turbine Div.
IN-LINE WEAR MONITOR Interim Report, Nov. 1985 - Jun. 1988
KEITH A. PIEPER and IVOR J. TAYLOR Sep. 1988 68 p
(Contract F33615-85-C-2537)
(AD-A201292; DDA EDR-13632; AFWAL-TR-88-2095) Avail: NTIS HC A04/MF A01 CSCL 21E

This report describes the construction and test results of an in-line monitor for critical ferrous and nonferrous metal debris in turbine engine lubrication systems. The in-line wear monitor (ILWM) is being developed by Allison Gas Turbine Division and a subcontractor, Princeton Gamma-Tech. The system uses the X-ray fluorescence principle for detecting metal debris on a continuous basis while the engine is running. The sensor portion of the system is engine mounted and contains a radioactive X-ray source, a flow cell to direct the oil across an X-ray permeable window, a proportional counter X-ray detector and its associated preamplifier and amplifier electronics. The data acquisition electronics is mounted on the airframe and contains a microprocessor based system for inputting pulses from the sensor, classifying and counting them according to energy bands, and analyzing the data and outputting metal concentration values to the engine monitoring system. GRA

N89-19302# Rolls-Royce Ltd., Derby (England).
PROPULSION
D. J. PICKERELL 15 Mar. 1988 30 p Presented at the Royal Aeronautical Society's 45th Oxford Air Transport Course, Oxford, England, Mar. 1988
(PNR90472; ETN-89-93675) Avail: NTIS HC A03/MF A01

The engine design criteria necessary to minimize direct operating costs for various types of operation are reviewed. Prospects for further reductions in fuel consumption including ultra high bypass ratio propulsion concepts are discussed. Long term prospects for second generation supersonic transport and hypersonic vehicles are described. ESA

N89-19303# Rolls-Royce Ltd., Derby (England).
THE GAS TURBINE ENGINE AND ITS CERTIFICATION
R. STIMPSON 1 Jul. 1988 16 p Presented at the United Kingdom Airworthiness Course, Canterbury, England, 1 Jul. 1988
(PNR90496; ETN-89-93690) Avail: NTIS HC A03/MF A01

The joint European engine requirements, already accepted by the UK and France are described as well as the certification compliance sheet used by the manufacturer to test each requirement. The tests include a 150 hr endurance test based on 6hr cycles at the highest allowed speed and temperature. The considerable effort put into the certification, product assurance and quality control in the production of gas turbine aero engines is shown. ESA

N89-19304# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. fuer Antriebstechnik.
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON SHOCKS LOSSES IN TRANSONIC AXIAL FLOW COMPRESSORS Ph.D. Thesis - Technische Hochschule, Aachen
REINER DUNKER Sep. 1988 231 p In GERMAN; ENGLISH summary
(DFVLR-FB-88-38; ISSN-0171-1342; ETN-89-93972) Avail: NTIS HC A11/MF A01; DFVLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Federal Republic of Germany, 80 deutsche marks

Shock models to be incorporated in an off-design performance prediction method for transonic axial flow compressor stages for more accurate flow prediction were developed. The improvement of shock models used for evaluating the shock losses, especially at supercritical subsonic, but also at supersonic inflow conditions, is emphasized. The methods were verified by calculating, investigating, and analyzing the losses of compressor cascades, as well as a transonic axial flow compressor. ESA

N89-19305*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ICING RESEARCH TUNNEL TEST OF A MODEL HELICOPTER ROTOR
THOMAS L. MILLER (Sverdrup Technology, Inc., Cleveland, OH.) and THOMAS H. BOND 1989 14 p Proposed for presentation at the 45th Annual Forum and Technology Display, Boston, MA, 22-24 May 1989; sponsored by the American Helicopter Society
(NASA-TM-101978; E-4677; NAS 1.15:101978) Avail: NTIS HC A03/MF A01 CSCL 21E

An experimental program has been conducted in the NASA Lewis Research Center Icing Research Tunnel (IRT) in which an OH-58 tail rotor assembly was operated in a horizontal plane to simulate the action of a typical main rotor. Ice was accreted on the blades in a variety of rotor and tunnel operating conditions and documentation of the resulting shapes was performed. Rotor torque and vibration are presented as functions of time for several representative test runs, and the effects of various parametric variations on the blade ice shapes are shown. This OH-58 test was the first of its kind in the United States and will encourage additional model rotor icing tunnel testing. Although not a scaled representative of any actual full-scale main rotor system, this rig has produced torque and vibration data which will be useful in assessing the quality of existing rotor icing analyses. Author

N89-19306# Rolls-Royce Ltd., Derby (England).
CURRENT DIAGNOSTIC PRACTICE IN GAS TURBINE COMBUSTORS
B. JONES 14 Sep. 1987 16 p Presented at the NATO/Advanced Study Institute on Instrumentation for Combustion and Flow in Engines, Vimeiro, Portugal, 14-25 Sep. 1987
(PNR90530; ETN-89-93702) Avail: NTIS HC A03/MF A01

Methods and equipment used for gas turbine engine performance assessment and research are illustrated. Internal flow; carbon deposition; film mixing; heat transfer measurement; fuel spray visualization; and combustion instability are considered. ESA

N89-19307# Rolls-Royce Ltd., Derby (England).
THE RELATIONSHIP BETWEEN MANUFACTURING TECHNOLOGY AND DESIGN
J. D. ALEXANDER and M. JEZIORO 6 Jun. 1988 7 p Presented at the 6th International Conference on Titanium: Titanium '88, Cannes, France, 6-9 Jun. 1988
(PNR90537; ETN-89-93704) Avail: NTIS HC A02/MF A01

It is argued that failures in aero engine components during service or development are frequently caused by a lack of understanding of the total engineering process. This process involves not only design, material selection, and stressing criteria but must include a detailed appreciation of the associated manufacturing processes. Only if the manufacturing constraints and their influence on microstructural development are fully understood can a consistent product be guaranteed to meet the engineering need. The design manufacturing interface is addressed from a processing manufacturing systems point of view. The type of philosophy which needs to be implemented if new titanium alloys and processing routes are to be more rapidly introduced for aero-engine components is identified. ESA

N89-19308# Rolls-Royce Ltd., Derby (England).
THE DIFFUSION BONDING OF AEROENGINE COMPONENTS
G. A. FITZPATRICK and T. BROUGHTON 6 Jun. 1988 7 p Presented at the 6th World Conference on Titanium: Titanium '88, Cannes, France, 6-9 Jun. 1988
(PNR90540; ETN-89-93705) Avail: NTIS HC A02/MF A01

The process parameters of diffusion bonding are recalled, and diffusion bonding applications for aeroengine components are described. A liquid-phase diffusion bonding process (activated diffusion bonding) for the manufacture of hollow titanium wide chord fan blades is presented. The development of a high integrity bond was fundamental to the design concept of this component. Solid-state diffusion bonding is utilized in the manufacture of hollow vane/blade airfoil constructions mainly in conjunction with superplastic forming and hot-forming techniques. ESA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A89-28550
DYNAMIC FEEDBACK LINEARIZATION WITH APPLICATION TO AIRCRAFT CONTROL
B. CHARLET, J. LEVINE (Paris, Ecole Nationale Superieure des Mines, Fontainebleau, France), and R. MARINO (Roma II, Universita, Rome, Italy) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 701-705. refs

The authors study the problem of the linearization of a nonlinear system by dynamic state feedback. A necessary condition and a sufficient condition are presented and are shown to apply to a general aircraft model. I.E.

A89-28551

DECOUPLING OF SYSTEMS WITH NEARLY SINGULAR I-O MAPS AND CONTROL OF AIRCRAFT

SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 706-711. refs
(Contract DAAL03-87-G-0004)

The author treats the control of a class of nonlinear systems using state variable feedback whose input-output map is nearly singular. A decoupling scheme is presented which gives rise to a singularly perturbed system describing the fast dynamics of the control vector. The quasi-steady-state solution of the system gives a control law which decouples the system in an approximate way. The controller includes a servocompensator and a reference trajectory generator. From this result a control law for approximate decoupling of roll angle, angle of attack, and sideslip in rapid, nonlinear airplane maneuvers is derived. Simulated responses of the closed-loop system show that large, simultaneous lateral and longitudinal maneuvers can be accurately performed in spite of uncertainty in stability derivatives. I.E.

A89-28585

ROBUST MODALIZED OBSERVER WITH FLIGHT CONTROL APPLICATION

K. M. SOBEL (City College, New York), S. S. BANDA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 1018, 1019.
(Contract F49620-87-R-0004)

The authors propose a method for designing modalized observers which achieves both small eigenvalue sensitivity and attenuation of the estimation error caused by an initial condition mismatch. The design approach is based on minimizing a cost function which depends on the norm of the observer modal matrix, its condition number, and directional information about the initial condition mismatch. The design method is compared with a previous approach to show its advantages. I.E.

A89-30617

FLY-BY-WIRE DESIGN CONSIDERATIONS

C. J. BERTHE, L. H. KNOTTS, J. H. PEER, and N. C. WEINGARTEN (Calspan Corp., Buffalo, NY) (Society of Experimental Test Pilots, Annual European Symposium, 20th, Linkoping, Sweden, June 1988) Cockpit (ISSN 0742-1508), Oct.-Dec. 1988, p. 4-15.

MIL-F-8785C, 'Military Specification for Flying Qualities of Piloted Airplanes', has codified the handling characteristics of classic aircraft for duplication by state-of-the-art fighters whose complex control systems often isolate the pilot from the 'feel' of the flight environment. Attention is presently given to the opportunities and difficulties faced by control system designers in the case of relaxed stability fly-by-wire fighter aircraft, with respect to the nonconventional response of the longitudinal axis, as well as time-delay effects, 'feel-system' dynamics, and the requisite flight-quality evaluation procedures. O.C.

A89-30678*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROSERVOELASTIC MODELING AND APPLICATIONS USING MINIMUM-STATE APPROXIMATIONS OF THE UNSTEADY AERODYNAMICS

SHERWOOD H. TIFFANY (NASA, Langley Research Center, Hampton, VA) and MORDECHAY KARPEL (Technion - Israel Institute of Technology, Haifa) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 265-274. refs
(AIAA PAPER 89-1188)

The theoretical basis of flexible-aircraft modeling techniques encompassing aerodynamic, control, and elastic-structure effects is investigated analytically, with a focus on methods which employ minimum-state approximations for the unsteady aerodynamics. Rational-function approximations to generalized aerodynamic forces are reviewed; constraints and lag-coefficient optimization are explained; the problem of physical weighting in the minimum-state equations of motion is examined; and results of typical analyses from the NASA Active Flexible Wing project (Perry et al., 1988) are presented in extensive tables and graphs and discussed in detail. The minimum-state approach is shown to produce accurate models at significantly reduced computation costs. T.K.

A89-30764*# Stanford Univ., CA.

IMPACT OF FLOW UNSTEADINESS ON MANEUVERS AND LOADS OF AGILE AIRCRAFT

M. AMEEN JARRAH and HOLT ASHLEY (Stanford University, CA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1069-1083. refs
(Contract NCA2-287; AF-AFOSR-84-0099)
(AIAA PAPER 89-1282)

A program of airload measurements on a family of low-aspect-ratio delta wings with sharp leading edges, subjected to large amplitude pitch transients with angles of attack up to 90 deg, is reviewed. Even for small values of the pitch-rate parameter, representative of maneuvers anticipated for agile aircraft, the force and moment overshoots can exceed by 50 percent their steady-state values. This is explained in terms of the hysteretic behavior of the breakdown locations of leading-edge vortices. An approximate theoretical model is proposed which includes the breakdown hysteresis as part of a three-term representation of the unsteady chordwise load distribution. V.L.

A89-30859*# Toledo Univ., OH.

APPLICATION OF A FULL-POTENTIAL SOLVER TO BENDING-TORSION FLUTTER IN CASCADES

MILIND A. BAKHLE, THEO G. KEITH, JR. (Toledo, University, OH), and KRISHNA RAO V. KAZA IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1982-1990. refs
(Contract NSG-3139)
(AIAA PAPER 89-1386)

A two-dimensional, unsteady, full-potential cascade aerodynamic code has been used for flutter calculations. The code, which uses a time-marching implicit scheme with internal Newton-iterations at each time step, allows oscillatory blade motions with phase lag between adjacent blades to be modeled using a single inter-blade passage. This aerodynamic code has been used with a two-degrees-of-freedom typical section structural model to determine the aeroelastic stability of a bladed disk. The unsteady pressure results calculated from the aerodynamic code have been verified by comparison with results from the linear and linearized potential theories. Flutter results have been presented for two cases. A comparison with linear theory shows identical trends; however, the present calculations show a lower flutter frequency. Author

A89-31100*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

DESIGN OF CONTROL LAWS FOR FLUTTER SUPPRESSION BASED ON THE AERODYNAMIC ENERGY CONCEPT AND COMPARISONS WITH OTHER DESIGN METHODS

E. NISSIM (NASA, Flight Research Center, Edwards, CA) AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and

Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989. 18 p. refs
(AIAA PAPER 89-1212)

The aerodynamic energy method is used in this paper to synthesize control laws for NASA's Drone for Aerodynamic and Structural Testing-Aerodynamic Research Wing 1 (DAST-ARW1) mathematical model. The performance of these control laws in terms of closed-loop flutter dynamic pressure, control surface activity, and robustness is compared against other control laws that appear in the literature and relate to the same model. A control law synthesis technique that makes use of the return difference singular values is developed in this paper. it is based on the aerodynamic energy approach and is shown to yield results superior to those given in the literature and based on optimal control theory. Nyquist plots are presented together with a short discussion regarding the relative merits of the minimum singular value as a measure of robustness, compared with the more traditional measure of robustness involving phase and gain margins. Author

A89-31451#

HIGH SPIN EFFECT ON THE DYNAMICS OF A HIGH L/D FINNED PROJECTILE FROM FREE-FLIGHT TESTS

ALAIN D. DUPUIS (Defence Research Establishment Valcartier, Courcelette, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 129-134. Previously cited in issue 22, p. 3538, Accession no. A87-49600.

A89-31456#

STRUCTURED STABILITY ROBUSTNESS IMPROVEMENT BY EIGENSPACE TECHNIQUES - A HYBRID METHODOLOGY

PIERRE R. APKARIAN (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 162-168. refs

A new hybrid design technique for improving stability robustness with respect to block-structured perturbations in multivariable linear feedback systems is presented. This new methodology is hybrid in that it uses both constrained optimization techniques for robustness and eigenstructure assignment for performance. This approach allows the designer to treat simultaneous perturbations occurring at different locations in the feedback system without having to compromise between robustness and performance. Performance requirements expressed in terms of closed-loop eigenvalues and right-eigenvectors are directly satisfied by the procedure. The realistic example of the SA365N DOLPHIN helicopter is presented to highlight the merits and some of the concerns in using this methodology. Author

A89-31460#

ACTIVE FLUTTER SUPPRESSION FOR TWO-DIMENSIONAL AIRFOILS

H. OHTA (Nagoya University, Japan), P. N. NIKIFORUK, M. M. GUPTA (Saskatchewan, University, Saskatoon, Canada), and A. FUJIMORI (Guidance and Control Conference, Seattle, WA, Aug. 20-22, 1984, Technical Papers, p. 535-543) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 188-194. Previously cited in issue 21, p. 2999, Accession no. A84-43460. refs
(Contract NSERC-A-5625; NSERC-A-1080)

A89-31462#

OBLIQUE WING AIRCRAFT FLIGHT CONTROL SYSTEM

R. N. CLARK (Washington, University, Seattle) and X. J. Y. LETRON (Aerospatiale, Toulouse, France) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 201-208. refs

A design procedure for a command and stability augmentation system (CSAS) for the oblique wing research airplane (OWRA) is presented. Three flight conditions are considered in which the wing skew angle is 0, 55, and 65 deg. The wing skew angle in the latter two cases induces severe asymmetrical dynamic behavior of the airframe. Five primary flight control surfaces are used to decouple the longitudinal motions from the lateral motions. The CSAS must accept conventional three-axis stick and rudder inputs from the pilot and translate these, along with feedback signals from the airframe, into the five airframe control surface commands. The design procedure combines eigenstructure design principles with an optimization scheme, providing a closed-loop response to both pilot inputs and to initial conditions that approximate those obtained with the wing in the unskewed position. The control surface deflections and rates required are within the capability of the OWRA for small-amplitude maneuvers. Author

A89-31856#

GUST LOAD ALLEVIATION OF A TRANSPORT-TYPE WING - TEST AND ANALYSIS

Y. MATSUZAKI (Nagoya University, Japan), T. UEDA, Y. MIYAZAWA, and H. MATSUSHITA (National Aerospace Laboratory, Chofu, Japan) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 233-241) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 322-327. Previously cited in issue 14, p. 2109, Accession no. A87-33677. refs

A89-31862#

ALGORITHMS FOR AIRCRAFT PARAMETER ESTIMATION ACCOUNTING FOR PROCESS AND MEASUREMENT NOISE

R. V. JATEGAONKAR and E. PLAETSCHKE (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 360-372. Research sponsored by DFG. refs

A comparison is made of four algorithms for parameter estimation in linear and nonlinear systems accounting for both process and measurement noise using two different approaches: direct approach and filtering approach. In the direct approach, the iterative Gauss-Newton method incorporating a suitable state estimator is used to estimate the unknown parameters by optimization of the likelihood function. For the state estimation both time-varying and steady-state filters are used. In the filtering approach, the unknown parameters are estimated as augmented states using the extended Kalman filter. The various algorithms are used to estimate from simulated as well as flight-test data the aircraft dimensional and nondimensional derivatives. Three model postulates, one linear and two nonlinear, are employed for this purpose. The parameter-estimation results indicate that the Gauss-Newton method with a steady-state filter, found to be adequate for the typical aircraft-estimation examples considered in the paper, is generally preferable. In the event that it becomes necessary to incorporate a time-varying filter, the filtering approach appears to be a viable alternative. Different aspects, such as convergence, computational time, parameter estimates, and their accuracies are evaluated for each of the four estimation algorithms. A general set of conclusions has been drawn. Author

A89-31864#

STATISTICAL-DISCRETE-GUST METHOD FOR PREDICTING AIRCRAFT LOADS AND DYNAMIC RESPONSE

J. G. JONES (Royal Aircraft Establishment, Farnborough, England) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 382-392. refs

The statistical-discrete-gust (SDG) method comprises a stochastic model for atmospheric turbulence and an associated technique for predicting the statistics of aircraft response. In the stochastic model, localized patterns of fluctuation are represented in terms of discrete ramp elements, and associated probability distributions are defined. With appropriate parameter settings, the model may be used to represent either continuous turbulence or relatively isolated gusts. The statistics of response, which may be linear or nonlinear, are derived by an application of the Laplace asymptotic approximation and are expressed in a form that shows the dominant influence of a particular tuned, or worst-case, gust pattern which is dependent on the aircraft dynamics. This paper reviews the basic concepts of the theory with particular reference to the incorporation of fractal representations of turbulence intermittency and to the problem of predicting the effects of nonlinear aircraft dynamics. The determination of numerical parameters from measured data is discussed, both for continuous turbulence and relatively isolated gusts. Author

N89-19310 Minnesota Univ., Minneapolis.
CONTROL OF NONLINEAR SYSTEMS USING PARTIAL DYNAMIC INVERSION Ph.D. Thesis
MICHAEL RAY ELGERSMA 1988 143 p
Avail: Univ. Microfilms Order No. DA8815802

Since linear control theory is well developed, methods for controlling nonlinear systems have focused on how to transform them into equivalent linear systems. Current research has centered on determining which nonlinear systems can be transformed into linear systems, and find methods for making the transformation. Whether or not a nonlinear system can be linearized depends on what class of transformations are allowed and on whether the transformations are required to be exact or only approximate. The class of systems considered is of the form x=f(x)+g(x)h(x,u) where x is the n-dimensional state, us is the m-dimensional control, and g(x) is an n x m matrix. This form allows the inclusion of certain types of nonlinearities in the control, while providing an affine structure in h. The function h can be considered the new control input, subject to constraints. Practical methods for controlling nonlinear systems were determined. The prototype nonlinear system studied here is a 6 degree-of-freedom nonlinear aircraft model. The method used to control this nonlinear aircraft model is called partial dynamic inversion. The generic six degree-of-freedom nonlinear aircraft model used is general enough to apply to almost any aircraft. The model includes nonlinear kinematics and aerodynamics as well as gravity and thrust. The aerodynamic functions can be general tabular functions of angle of attack, side-slip angle, and Mach. A closed form solution is given for the aircraft equilibrium equations. Since the model had four control inputs, the equilibrium set is four dimensional. Dissert. Abstr.

N89-19311 Michigan Univ., Ann Arbor.
MINIMAX AND MAXIMAX OPTIMAL CONTROL PROBLEMS WITH APPLICATIONS IN AEROSPACE ENGINEERING Ph.D. Thesis
PING LU 1988 144 p
Avail: Univ. Microfilms Order No. DA8821615

Some previous work on the so-called Chebyshev minimax problem is reviewed. An extended theorem of optimal control is given that is part of the theoretical foundation in the following discussion. A set of practical yet sufficiently general necessary conditions for minimax and maximax problems is derived. Some of the previous work on the minimax problem is shown to be the special cases of our necessary conditions. The effect of the discontinuity of adjoint states on controls is exploited for the first time and the significant difference between the minimax and maximax problems is revealed. Analytical examples are presented to verify all aspects of the results. As an application of the maximax problem in aerospace engineering, the maximization of the flight radius of a hypervelocity aeroglider is discussed thoroughly and numerical results are given. One of the important applications of the minimax problem is the minimization of the peak heating rate and the peak deceleration of a trans-atmospheric vehicle. Some characteristics of the problem are investigated and the control property is analyzed with the aid of necessary conditions. Numerical experiments are carried out to verify the analysis. Dissert. Abstr.

N89-19312 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
TIME PERIODIC CONTROL OF A MULTIBLADE HELICOPTER Ph.D. Thesis
STEVEN GARNETT WEBB 1988 217 p
Avail: Univ. Microfilms Order No. DA8821884

The flap-lag equations of motion of an isolated rotor blade and those for a rigid helicopter containing four blades free to flap and lag are derived. Control techniques are developed which stabilize both systems for a variety of flight conditions. Floquet theory is used to investigate the stability of a rotor blade's flap-lag motion. A modal control technique, based on Floquet theory, is used to eliminate the blade's instabilities using existing collective and cyclic pitch control mechanisms. The technique shifts the unstable roots to desired locations while leaving the other roots unaltered. The control, developed for a single design point, is shown to significantly reduce or eliminate regions of flap-lag instabilities for a variety of off design conditions. Both scalar and vector control are successfully used to stabilize the blade's motion. Dissert. Abstr.

N89-19314# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
A SYSTEMS APPROACH TO ROTORCRAFT STABILITY AND CONTROL RESEARCH Final Report, 1 Sep. 1986 - 31 Oct. 1988
D. P. SCHRAGE, J. V. PRASAD, C. M. MCKEITHAN, B. H. TONGUE, P. FITZSIMMONS, and D. TEARE 24 Oct. 1988 26 p
(Contract DAAL03-86-K-0160)
(AD-A201784; ARO-23246.1-EG) Avail: NTIS HC A03/MF A01 CSCL 20D

Helicopters exhibit undesireable dynamic characteristics due to strong coupling that exists between longitudinal and lateral modes. In addition to being unstable at hover and low forward flight speeds, the helicopter has significantly different dynamic modal characterizing in hover and low speeds as compared to forward flight. For example, in hover, the body translational motion and pitching motion are decoupled from the heaving motion. In forward flight, the pitching motion and the vertical motion are strongly coupled. These dissimilar characteristics in hover and forward flight make piloting techniques more difficult and increase pilot workload and degrade handling qualities. This research has attempted a systems approach to rotorcraft stability and control. GRA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A89-29210#
WIND TUNNEL AIR INTAKE TEST TECHNIQUES
JACKY LEYNAERT (ONERA, Chatillon-sous-Bagneux, France) (Institut von Karman de Dynamique des Fluides, Lecture Series, Brussels, Belgium, Feb. 22-26, 1988) ONERA, TP, no. 1988-20, 1988, 30 p. refs
(ONERA, TP NO. 1988-20)

The development of aircraft propulsion system air intake testing methods over the last decade is presently noted to have progressed in the direction of large-scale intake testing, with detailed digitized analysis of the steady and unsteady flow in order to guide CFD efforts for the given installation. Attention is presently given to intake test parameters and the effects on various kinds of interference on them, the state-of-the-art in subsonic transport aircraft intake mass-flow and cowl drag testing, combat aircraft and SST air intake internal flow tests and nacelle external drag, and special test methods for total internal flow probing. O.C.

A89-29244#
START AND UNSTART IN S2 SUPERSONIC WIND TUNNEL IN ONERA MODANE-AVRIEUX CENTER
F. CHARPIN and P. HUGOUVIEUX (Supersonic Tunnel Association, Semi-Annual Meeting, 69th, Los Angeles, CA, May 23, 24, 1988) ONERA, TP, no. 1988-79, 1988, 31 p.
(ONERA, TP NO. 1988-79)

To investigate the mechanism of the flow breakdown in a S2 wind tunnel at the ONERA Modane-Avrieux center, a measurement system was designed, which makes it possible to visualize in real time the variations of the Mach number distributions along the walls of the first throat, the test section, the second throat, and the diffuser. The measurement system consists of a set of pressure multitransducers producing the instantaneous Mach number distributions. Several cases are presented which clearly show the effectiveness of the device, and the monitoring and surveillance possibilities. I.S.

A89-29270#

EXPERIMENTAL STUDY OF THE CONNECTION BETWEEN A LONG SPARK AND AN AIRCRAFT MOCK-UP

G. LABAUNE, F. ISSAC, J. P. MOREAU, A. BONDIOU, J. C. ALLIOT (ONERA, Chatillon-sous-Bagneux, France) et al. (International Conference on Gas Discharges and their Applications, 9th, Venice, Italy, Sept. 19-23, 1988) ONERA, TP, no. 1988-118, 1988, 5 p. Research supported by DRET. refs

(ONERA, TP NO. 1988-118)

An experiment to study the relationship between long-gap atmospheric pressure electric discharge and an aircraft is examined. The experiment uses an aircraft mock-up and a high-voltage Marx generator which can reach G MV in both polarities with rise times varying from one to a few hundreds of microseconds. It is found that the stepped propagation of the discharge induces an impulsive behavior of the surface electric and mangetic fields. The peak values time derivatives of the electric and magnetic fields are 1.5 X 10 to the 13th V/m/s and 10 to the 11th A/m/s, respectively. These values are slightly larger than in-flight values (Moreau and Alliot, 1986). R.B.

A89-29284#

S4MA HYPERSONIC FACILITY - INFLUENCE OF THE EJECTOR-DIFFUSER DESIGN

J. P. LEDY (Supersonic Tunnel Association, Semi-Annual Meeting, 69th, Los Angeles, CA, May 23, 24, 1988) ONERA, TP, no. 1988-133, 1988, 24 p.

(ONERA, TP NO. 1988-133)

An account is given of the design features and performance characteristics of ONERA's Modane-Avrieux S4, Mach 6-capable hypersonic wind tunnel, in the wake of its incorporation of a new 550-mm diameter diffuser; test data thus obtained are compared with data from the initially employed 780-mm diameter diffuser. The redesign effort had as its goals the lengthening of blowdown operations and the increase of such operations per day, as well as the ability to start the Mach 6 nozzle at 40-bar stagnation pressure with simple atmospheric exhaust, in order to obviate current dependency of installations of this type on vacuum chambers. Useful blowdown time has been doubled, and the starting pressure ratio has been substantially reduced. O.C.

A89-29288* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

CRYOGENIC WIND TUNNEL RESEARCH - A GLOBAL PERSPECTIVE

D. A. DRESS and R. A. KILGORE (NASA, Langley Research Center, Hampton, VA) Cryogenics (ISSN 0011-2275), vol. 28, Jan. 1988, p. 10-21. refs

The development of cryogenic wind tunnels is reviewed and 13 cryogenic wind tunnels currently operating in England, France, Germany, Japan, and the U.S. are described. A table illustrating the characteristics of these tunnels is presented, including test gases, test section sizes, speed ranges, stagnation pressure and temperature, and running time. The research conducted using the various wind tunnels is outlined and the operation of each of the tunnels is considered. R.B.

A89-29347

NASA WILL STUDY HEAVY RAIN EFFECTS ON WING AERODYNAMICS

EDWARD H. PHILLIPS Aviation Week and Space Technology (ISSN 0005-2175), vol. 130, Feb. 13, 1989, p. 38, 39, 41.

NASA-Langley will undertake studies of the heavy rain associated with wind shear phenomena on transport aircraft aerodynamics. In these tests, for which a unique 2200-ft long apparatus has been designed and constructed, a carriage structure will carry a 13-ft span, 10-ft chord NACA 64-210 airfoil-based wing section with deployed leading-edge slat and double-slotted trailing edge flap to simulate an airliner wing's landing configuration. The carriage is capable of speeds up to 220 knots; it will be subjected to rain rates of 2-, 10-, 30-, and 40-inches/hr. The experiments thus conducted should also shed light on the effects of rainfall on canard-configuration aircraft. O.C.

A89-29511

INVESTIGATION OF AEROACOUSTIC MECHANISMS BY REMOTE THERMAL IMAGING

ALAN J. WITTEN and GEORGE E. COURVILLE (Oak Ridge National Laboratory, TN) IN: Thermal infrared sensing for diagnostics and control (Thermosense X); Proceedings of the Meeting, Orlando, FL, Apr. 5-8, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 207-214.

The thermal structure of the exhaust gas from an aircraft turbojet engine is investigated by means of IR thermography, in an effort to identify the mechanism producing subaudible acoustic emission observed near engine diagnostic-test facilities (hush houses). The various sources of engine noise are reviewed; the structure of the hush house is characterized; theoretical models of hot turbulent jets are discussed; and images obtained with an IR camera operating at 8-14 microns, equipped with a 45-deg wide-angle lens, and mounted 20-40 ft from the engine are presented and analyzed. Two distinct flow regions are identified: (1) a highly turbulent region at some distance downstream and (2) a near-source laminar region in which the growth of the self-excited instability wave and the transition to turbulence are suppressed by the emission of low-frequency acoustic Cerenkov radiation (as predicted by theory). T.K.

A89-29655*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MAGNETS PROMISE PRODUCTIVITY

PIERCE L. LAWING, ROBERT A. KILGORE, and DAVID A. DRESS (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 27, March 1989, p. 34-36, 38.

The use of advanced magnetic suspension and balance systems (MSBS) in wind tunnels is examined. The advantages of MSBS are discussed, including accurate dynamic stability and free manipulation of the model aircraft allowing the free-flying model to respond dynamically to aerodynamic forces. Examples of wind tunnel tests employing MSBS are presented, including tests of a hypersonics parasol wing configuration and the simulation of the ejection of the crew-escape module from an aircraft. R.B.

A89-29737

FLIGHT SIMULATORS - CONCEPTS AND DEVELOPMENT TRENDS [FLUGSIMULATOREN - BEGRIFFE UND ENTWICKLUNGSTENDENZEN]

RALF LINDNER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 6, 1988, p. 217-220. In German. refs

The state of the art and development trends in western flight simulator technology is addressed. Phases in the development of a flight simulators are outlined, and the component parts of a full-scale modern flight simulator are described. The role of the computer in the flight simulator is emphasized. Economic and legal aspects are considered. C.D.

A89-30648#

AIRPORT REQUIREMENTS FOR THE IL-96 AND TU-204 AIRCRAFT [WYMAGANIA WOBEC PORTOW LOTNICZYCH DLA SAMOLOTOW IL-96 I TU-204]

KAZIMIERZ GILEWSKI and LUDWIK GRUCHALSKI Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, July 1988, p. 17. In Polish.

A89-31823#
LABORATORY SIMULATION OF THE ATTACHMENT OF A LEADER TO A SUSPENDED AIRCRAFT MOCKUP [SIMULATION EN LABORATOIRE DE L'ATTACHEMENT D'UN LEADER A UNE STRUCTURE FLOTTANTE]
GERARD LABAUNE, FRANCOIS ISSAC, JEAN-PATRICK MOREAU, ANNE BONDIOU, JEAN-CLAUDE ALLIOT (ONERA, Chatillon-sous-Bagneux, France) et al. (Societe des Electriciens, des Electroniciens et des Radio-Electriciens, Journees d'Etude sur les Recents Progres dans les Recherches sur la Foudre, Gif-sur-Yvette, France, Nov. 23, 24, 1988) ONERA, TP, no. 1988-165, 1988, 8 p. In French. refs
(ONERA, TP NO. 1988-165)

Laboratory experiments on the interaction between sparks and electrically suspended structures were performed in order to study leader/aircraft attachment. Based on results obtained for point-plane and plane-plane configurations, four stages are identified for the spark/structure attachment process. The results suggest that the slow variation of electric field observed during in-flight experiments at the beginning of the attachment process is related to the development of a discharge originating on the aircraft itself. R.R.

A89-31860#
INTEGRATION OF MANNED SIMULATION AND FLIGHT TEST INTO OPERATIONAL TESTING AND EVALUATION
M. J. WILLIAMS and M. A. HARTFORD (McDonnell Douglas Corp., Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 26, April 1989, p. 349-353. Previously cited in issue 03, p. 288, Accession no. A88-14272.

N89-18498*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
HIGH TEMPERATURE FURNACE MODELING AND PERFORMANCE VERIFICATIONS Semiannual Progress Report, Mar. - Sep. 1988
JAMES E. SMITH, JR. Oct. 1988 26 p
(Contract NAG8-708)
(NASA-CR-183381; NAS 1.26:183381) Avail: NTIS HC A03/MF A01 CSCL 14B

Analytical, numerical and experimental studies were performed on two classes of high temperature materials processing furnaces. The research concentrates on a commercially available high temperature furnace using zirconia as the heating element and an arc furnace based on a ST International tube welder. The zirconia furnace was delivered and work is progressing on schedule. The work on the arc furnace was initially stalled due to the unavailability of the NASA prototype, which is actively being tested aboard the KC-135 experimental aircraft. A proposal was written and funded to purchase an additional arc welder to alleviate this problem. The ST International weld head and power supply were received and testing will begin in early November. The first 6 months of the grant are covered. Author

N89-18499*# University of the Pacific, Stockton, CA. Dept. of Mechanical Engineering.
WIND TUNNEL PRESSURIZATION AND RECOVERY SYSTEM Final Report
EDWIN R. PEJACK, JOSEPH MEICK, ADNAN AHMAD, NORDIN LATEH, and OMAR SADEQ Dec. 1988 94 p
(Contract NAG2-505)
(NASA-CR-184591; NAS 1.26:184591) Avail: NTIS HC A05/MF A01 CSCL 14B

The high density, low toxicity characteristics of refrigerant-12 (dichlorofluoromethane) make it an ideal gas for wind tunnel testing. Present limitations on R-12 emissions, set to slow the rate of ozone deterioration, pose a difficult problem in recovery and handling of large quantities of R-12. This preliminary design is a possible solution to the problem of R-12 handling in wind tunnel testing. The design incorporates cold temperature condensation with secondary purification of the R-12/air mixture by adsorption. Also discussed is the use of Freon-22 as a suitable refrigerant for the 12 foot wind tunnel. B.G.

N89-18500*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROTARY BALANCES: A SELECTED, ANNOTATED BIBLIOGRAPHY
MARIE H. TUTTLE (Vigyan Research Associates, Inc., Hampton, VA.), ROBERT A. KILGORE, and KAREN L. SYCH Mar. 1989 26 p
(NASA-TM-4105; L-16508; NAS 1.15:4105) Avail: NTIS HC A03/MF A01 CSCL 14B

This bibliography on rotary balances contains 102 entries. It is part of NASA's support of the AGARD Fluid Dynamics Panel Working Group 11 on Rotary Balances. This bibliography includes works that might be useful to anyone interested in building or using rotor balances. Emphasis is on the rotary balance rigs and testing techniques rather than the aerodynamic data. Also included are some publications of historical interest which relate to key events in the development and use of rotary balances. The arrangement is chronological by date of publication in the case of reports and by presentation in the case of papers. Author

N89-19318# Naval Postgraduate School, Monterey, CA.
AEROTHERMODYNAMICS OF A JET CELL FACILITY M.S. Thesis
ERIC A. NICOLAUS Sep. 1988 151 p
(AD-A202142; AD-E501048) Avail: NTIS HC A08/MF A01 CSCL 21E

This thesis consists of a three-dimensional numerical analysis of the Jet Aircraft Hush House located at Naval Air Station Jacksonville, Florida. Utilizing the PHOENICS Code allows for the determination of the aerothermal characteristics including velocity, pressure, enthalpy, turbulent kinetic energy and the dissipation rate of turbulent kinetic energy in the facility during testing of the U.S. Navy's F-4 (Phantom II) J-79-GE-8 gas turbine engine with afterburner. How and by what method PHOENICS arrives at this solution is discussed. Of greatest importance is the resulting behavior of the aerothermal system. Problems encountered using the PHOENICS code, resulting numerical solutions to the particular facility, comparison to actual test data and recommendations for further applications of the PHOENICS Code are presented. GRA

N89-19319# Royal Aerospace Establishment, Farnborough (England).
AIRFIELD LIGHTING: FUTURE TRENDS
A. J. SMITH Aug. 1988 22 p Presented at the Illuminating Engineering Society of North America/Aviation Lighting Division Conference, DC, 10-13 Oct. 1988
(RAE-TM-FM-6; BR107591; ETN-89-93671) Avail: Defence Research Information Centre, 65 Brown Street, Glasgow, G2 8EX Scotland

Approach and runway lighting for fixed wing precision approaches is reviewed. The importance of equipment maintenance is emphasized. Requirements for visual aids to support helicopter operations and to enhance surface movement, guidance, and control are considered. ESA

10

ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A89-30536
THE PROSPECTS FOR EUROPEAN AEROSPACE TRANSPORTERS. II - A DESIGN CONCEPT FOR A MINIMUM-COST AEROSPACE TRANSPORTER

P. Q. COLLINS (Imperial College of Science and Technology, London, England) and D. M. ASHFORD Aeronautical Journal (ISSN 0001-9240), vol. 93, Feb. 1989, p. 39-49. refs

Short-term ESA requirements for a minimum development cost fully-reusable aerospace launch vehicle, such as an eight-crewmember/750-kg payload capacity, the use of existing man-rated powerplants, and operation from existing airfields, are discussed and used as the basis for elaborating a two-stage booster/orbiter system design incorporating technology from such recent projects as Concorde, Spacelab, Ariane, and the Space Shuttle. It is ascertained that the development costs of such a vehicle will be lower than those of the semireusable Hermes/Ariane 5 combination. O.C.

A89-31567
AN OPTION FOR MECHANIZING INTEGRATED GPS/INS SOLUTIONS
J. ARNOLD SOLTZ, JAMES I. DONNA, and RICHARD L. GREENSPAN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) Navigation (ISSN 0028-1522), vol. 35, Winter 1988-1989, p. 443-457. refs

The method for the integration of GPS measurements with INS outputs with a system with requirements that exceed GPS specification is presented. The method involves mechanizing an independent navigation filter in a host vehicle mission computer. The adjustment of receiver parameters to effect filter tuning and the improvements which can be made from filter tuning are examined. The INS characteristics which should be considered when selecting tuning parameters are outlined. R.B.

11

CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A89-29100
ELEMENTAL EFFECTS ON CAST 718 WELDABILITY
T. J. KELLY (GE Engineering Materials Technology Laboratories, Cincinnati, OH) Welding Journal, Research Supplement (ISSN 0043-2296), vol. 68, Feb. 1989, p. 44-s to 51-s. refs

This paper demonstrates that the microcracking problem with cast alloy 718 is due to its principal alloying elements and is judged to be unavoidable without a major change in alloy chemistry. The concept of weldability in this study is the ability to resist heat-affected zone microcracking during fusion welding. This was measured by the number of cracks and the total crack length produced in a 2 percent augmented strain Spot Varestraint test. Statistical results are presented, summarizing the elemental effects on the weldability of alloy 718. The primary cause of microcracking is the boron content, followed by the iron and niobium content, all of which are required alloying elements. S.A.V.

A89-29159
INTERMETALLIC COMPOUNDS FOR HIGH-TEMPERATURE STRUCTURAL USE
A. I. TAUB and R. L. FLEISCHER (GE Research and Development Center, Schenectady, NY) Science (ISSN 0036-8075), vol. 243, Feb. 3, 1989, p. 616-621. refs
(Contract N00014-86-C-0353)

The next generation of efficient turbines and engines will require materials that can withstand operating temperatures approaching 2000 C. Intermetallic compounds with high melting temperatures are candidates for this application, but the obstacle of their limited ductility must first be overcome. Because the available data on these materials is limited, a survey of the effects of chemistry and crystal structure must be performed. With the use of melting temperature and density as figures of merit, the most likely candidates have been identified for preliminary screening.
Author

A89-29203#
TENSILE BEHAVIOUR OF A NICKEL-BASED SINGLE CRYSTAL SUPERALLOY - EFFECTS OF TEMPERATURE AND ORIENTATION
P. CARON and T. KHAN (ONERA, Chatillon-sous-Bagneux, France) (Symposium on Advanced Materials and Processing Techniques for Structural Applications, Paris, France, Sept. 7-9, 1987) ONERA, TP, no. 1988-7, 1988, 13 p. refs
(ONERA, TP NO. 1988-7)

Nickle-based single crystal superalloys are specifically developed for blade and vane applications in advanced gas turbine engines. Absence of grain boundaries, preferred 001-line orientation along the blade axis, and development of compositions suitable for single crystal growth provide significant improvement in creep and fatigue strength over conventionally cast superalloys. Although the blade is essentially subjected to centrifugal loading along the 001-line direction, some multiaxial stresses are generated locally due to the complex shape of the blade root or, in some cases, because of the presence of intricate cooling schemes in the airfoil. Thus, an important requirement for a proper design of single crystal blades is the development of constitutive models for such anisotropic materials. The crystallographic approach for modeling requires, in particular, the identification of active slip systems as a function of temperature and orientation. One of the objectives of this work is to contribute to the development of such a model by characterizing the tensile behavior of the CMSX-2 single crystal superalloy at room temperature, 650, 760 and 950 C for various orientations. A further objective is to study the basic deformation mechanisms operating during tensile tests of this single crystal superalloy. Author

A89-29278#
MODELLING OF VISCOPLASTIC ANISOTROPIC BEHAVIOUR OF SINGLE CRYSTALS
G. CAILLETAUD (Paris, Ecole Nationale Superieure des Mines, Evry, France), D. NOUAILHAS, and P. POUBANNE (ONERA, Chatillon-sous-Bagneux, France) (International Seminar on the Inelastic Behaviour of Solids: Models and Utilization, Besancon, France, Aug. 30-Sept. 1, 1988) ONERA, TP, no. 1988-127, 1988, 14 p. Research supported by SNECMA. refs
(ONERA, TP NO. 1988-127)

This paper deals with the description of the behavior of nickel-base single-crystal superalloys under monotonic and cyclic loading conditions at high temperature. After a presentation of some experimental results obtained on the AM1 alloy at 950 C, a discussion is conducted on the ways of modeling anisotropic viscoplastic behavior. Two approaches are presented: a micro-macro modeling, based on the slip theory, and a macroscopic one, using the formalism of the tensorial functions theory.
Author

A89-29297* Santa Clara Univ., CA.
THERMAL PROTECTION STUDIES OF PLASTIC FILMS AND FIBROUS MATERIALS
MICHEL A. SAAD (Santa Clara University, CA) and ROBERT L. ALTMAN (NASA, Ames Research Center, Moffett Field, CA) Journal of Fire Sciences (ISSN 0734-9041), vol. 6, July-Aug. 1988, p. 250-266. refs
(Contract NCA2-OR-685-302)

The thermal protection properties of various film and woven materials were studied using an experimental method of radiant heating. The materials studied included aluminized and unaluminized synthetic plastic films and fibrous materials like silicon carbide and phenolic novolac. It is shown that a thin metallized coating with good reflectivity significantly enhances the heat blocking capability of a variety of insulative materials. K.K.

A89-29458* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

WATER INTRUSION IN THIN-SKINNED COMPOSITE HONEYCOMB SANDWICH STRUCTURES

WADE C. JACKSON and T. KEVIN O'BRIEN (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 36 p. refs

Thin-skinned composite honeycomb sandwich structures from the trailing edge of the U.S. Army's Apache and Chinook helicopters have been tested to ascertain their susceptibility to water intrusion as well as such intrusions' effects on impact damage and cyclic loading. Minimum-impact and fatigue conditions were determined which would create microcracks sufficiently large to allow the passage of water through the skins; damage sufficient for this to occur was for some skins undetectable under a 40X-magnification optical microscope. Flow rate was a function of moisture content, damage, applied strain, and pressure differences. O.C.

A89-29461

EDGE EFFECTS IN TAPERED COMPOSITE STRUCTURES

JOHN C. FISH (McDonnell Douglas Helicopter Co., Mesa, AZ) and SUNG W. LEE (Maryland, University, College Park) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 16 p. refs (Contract DAAG29-83-K-002)

The tensile strength of quasi-isotropic tapered composite laminates with multiple internal ply drop steps is investigated. Both experimental testing of glass-epoxy coupon specimens and finite element modeling of the tapered laminates are conducted. The interlaminar stress states created by the free-edge effect and the internal ply drops were determined using a quasi-three-dimensional finite element model of a laminate cross-section and a three-dimensional model of the tapered geometry, respectively. Both models incorporated an interply resin layer at the delamination prone ply interface. The average stress concept was applied to the two interlaminar stress states, which were superimposed near the root of the taper, and a quadratic delamination failure criterion was used to predict delamination onset. Strength predictions based on failure of the interply resin correlated well with the experimentally determined strengths. Author

A89-29653#

NEW LIFE FOR ALUMINUM

RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 27, March 1989, p. 26-29.

The use of aluminum in composites and as a matrix for materials reinforcement is examined. The materials discussed include ingot-grade composites aluminum and alumina or silicon carbide, an aluminum lithium matrix, an optical-grade aluminum metal matrix, and aluminum sheets laminated between layers of aramid epoxy. The advantages of using aluminum in composite materials are discussed. R.B.

A89-29957

LOW ENERGY CURED COMPOSITE REPAIR SYSTEM

FRANK LEE, SUSAN BRINKERHOFF, and STELLA MCKINNEY (Hexcel Corp., Dublin, CA) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 60-71. refs

A low-energy cured composite repair system (termed 639-107) designed to meet all the field and depot repair requirements is described. The thermal and laminate properties of the 639-107 system are very similar to those of a typical 350-F cured epoxy prepreg resin. The room-temperature shelf life is at least one year, with excellent tack retained beyond that time. Unlike most of the reported repair systems which usually have to be cured at 250-300 F, the 639-107 system can be cured at 200 F under vacuum-bag condition. I.S.

A89-29962

THERMAL AGEING OF POLY(ARYL-ETHER-ETHER KETONE) (PEEK) - THE ROLE OF CARBON

M. DAY, T. SUPRUNCHUK, J. D. COONEY, and D. M. WILES (National Research Council of Canada, Div. of Chemistry, Ottawa) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 132-143. refs

The effects of thermal treatment conditions and test environment on the morphology and the crystallization kinetics of PEEK were investigated using differential scanning calorimetry. The results showed that holding PEEK in the melt at 400 C causes a reduction in the quantity of crystallizable material and in the rate at which it recrystallizes. The longer the hold time, the greater the reduction, with the largest reduction registered in air and in the presence of carbon fibers. Heating PEEK samples at 400 C in air for periods longer than 60 min eliminates the crystalline nature of PEEK altogether. I.S.

A89-30065

MODELING OF THE UNSTEADY THERMAL-STRESS STATES OF COOLED GAS TURBINE BLADES [MODELIROVANIE NEUSTANOVIVSHIKHSIA TERMONAPRIAZHENNYKH SOSTOIANII OKHLAZHDAEMYKH LOPATOK GAZOVYKH TURBIN]

G. N. TRET'IACHENKO, B. S. KARPINOS, and V. E. ANDREEV (AN USSR, Institut Problem Prochnosti; Kievskoe Vysshee Voennoe Aviatsionnoe Inzhenernoe Uchilishche, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Jan. 1989, p. 68-71. In Russian. refs

A method for modeling the thermal-stress state of the leading edge of a cooled nozzle diaphragm blade of a gas turbine is proposed which involves testing of elliptical cylinders stiffened by partitions in a gas flow. A regression equation is presented which relates maximum thermal stresses in the heating or cooling half-cycle to the design parameters of the model. The method is illustrated by an example. V.L.

A89-30086

HIGH-VISCOSITY AND BITUMENOUS OILS - PROMISING RAW MATERIALS FOR THE PRODUCTION OF JET AND DIESEL FUELS [VYSOKOVIAZKIE I BITUMNYE NEFTI - PERSPEKTIVNOE SYR'E DLIA POLUCHENIIA REAKTIVNYKH I DIZEL'NYKH TOPLIV]

N. M. LIKHTEROVA, G. R. AVDZHIEV, and A. F. GORENKOV Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 1, 1989, p. 7-9. In Russian. refs

High-viscosity oils and natural bitumens containing more than 25 percent of resinous-asphaltene components and having a density of greater than 935 kg/cu m are investigated as possible raw materials for the production of aviation jet fuels. In particular, the composition and properties of bitumens from various deposits are briefly reviewed, and a scheme for the processing of bitumenous sandstone is presented. Jet fuels produced from bitumens are characterized with reference to their physicomechanical properties. V.L.

A89-30087

EFFECT OF VIBRATION ON THE DEHUMIDIFIER-ANTICOAGULANT CONTENT OF JET FUELS [VLIIANIE VIBRATSII NA SODERZHANIE PROTIVOVODOKRISTALLIZATSIONNOI ZHIDKOSTI V REAKTIVNOM TOPLIVE]

B. G. BEDRIK, V. N. GOLUBUSHKIN, and N. M. LIKHTEROVA Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 1, 1989, p. 21, 22. In Russian.

It has been shown in a previous study (Bedrik et al., 1983) that the water content of jet fuels tends to increase in the presence of dehumidifier-anticoagulants, such as ethyl Cellosolve. This leads to increased formation of emulsions and aqueous liquid-phase residue. The objective of the present study is to investigate the effect of vibration, a constantly present factor, on the formation of liquid-phase residue. It is shown experimentally that, in the absence of water, dehumidifier-anticoagulant content in fuels remains practically unchanged under conditions of vibration. In the presence of aqueous residue, vibration is found to substantially increase the precipitation of the dehumidifier-anticoagulant. V.L.

A89-30492#
VARIABLE GEOMETRY CONTROL OF REACTING SHEAR LAYERS
U. G. HEGDE, D. M. REUTER, and B. T. ZINN (Georgia Institute of Technology, Atlanta) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 9 p. refs
(Contract N00014-84-K-0470)
(AIAA PAPER 89-0979)

This paper is concerned with the control of reacting shear layers in propulsive devices such as ramjets and jet engine afterburners. Specifically, the influence of the flame zone geometry on combustion instability and unsteady heat release rates is investigated experimentally. It is shown that the magnitude, phase and frequency of the unsteady heat release rates from different regions of the reacting shear layer are strongly dependent upon the relative distances between the flame holders in the combustion zone. The reasons for this dependence are investigated and the feasibility of geometrical control of combustion instabilities is demonstrated. Author

A89-31332
FAST NUMERICAL TECHNIQUE FOR NOZZLE FLOWS WITH FINITE-RATE CHEMICAL KINETICS
DIEGO LENTINI and MARCELLO ONOFRI (Roma I, Universita, Rome, Italy) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 449-460. refs

A fast numerical technique for nonequilibrium chemically reacting gaseous flows is presented. The method is based on the lambda-formulation and on a fast-converging semiimplicit solver of the equations of continuity, momentum, and energy, and a fully implicit solver of the species continuity equations. Any given nozzle shape can be considered. Results are worked out for a typical ramjet nozzle flow, and prove to compare favorably with those obtained by other authors in terms of both accuracy and computing time. Author

A89-31778
FATIGUE CRACK PROPAGATION IN ARALL LAMINATES - MEASUREMENT OF THE EFFECT OF CRACK-TIP SHIELDING FROM CRACK BRIDGING
R. O. RITCHIE, WEIKANG YU (California, University, Berkeley), and R. J. BUCCI (Alcoa Laboratories, Alcoa Center, PA) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 32, no. 3, 1989, p. 361-377. refs
(Contract AF-AFOSR-87-0158)

The effects of extrinsic toughening mechanisms on fatigue crack propagation in 1.35-mm-thick 3/2 ARALL laminates are investigated experimentally. CT specimens are subjected to standard fatigue tests, fractographic examination, and crack-tip shielding measurements; the results are presented in extensive graphs and micrographs and characterized in detail. Extensive crack bridging from unbroken aramid fibers is observed in a zone of length up to 5 mm in the wake of the crack, leading to reduced maximum stress intensity near the crack tip; fiber rupture is limited by weak fiber-matrix bonding. T.K.

A89-32276
STABILIZATION OF T-6 FUEL BY S-789 INHIBITOR AND COMPOSITIONS BASED ON IT [STABILIZATSIIA TOPLIVA T-6 INGIBITOROM S-789 I KOMPOZITSIIAMI NA EGO OSNOVE]
T. P. VISHNIAKOVA, I. A. GOLUBEVA, L. P. GUTNIKOVA, L. A. SKRIPKO, and V. L. TROSTIANETSKAIA (Moskovskii Institut Neftekhimicheskoi i Gazovoi Promyshlennosti, Moscow; Nauchno-Issledovatel'skii Institut Khimikatov dlia Polimernykh Materialov, USSR) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 2, 1989, p. 21, 22. In Russian. refs

The development of antioxidants effective over a wide temperature range is essential for solving the problem of the reliable stabilization of jet fuels. Here, the inhibiting efficiency of the aromatic amine S-789 and compositions with its phenol antioxidants is evaluated by the methods of 12-time heating at 120 C and oxidation within a closed volume at 180 C. With reference to results obtained for T-6 fuel, it is shown that S-789 is a much more efficient antioxidant than phenol compounds. Details of the experimental procedure and test results are presented. V.L.

N89-18530*# California Polytechnic State Univ., San Luis Obispo.
MEASURED AND PREDICTED STRUCTURAL BEHAVIOR OF THE HIMAT TAILORED COMPOSITE WING Final Report
LAWRENCE H. NELSON Mar. 1987 92 p
(Contract NCA2-6)
(NASA-CR-166617; H-1376; NAS 1.26:166617) Avail: NTIS HC A05/MF A01 CSCL 11D

A series of load tests was conducted on the HiMAT tailored composite wing. Coupon tests were also run on a series of unbalanced laminates, including the ply configuration of the wing, the purpose of which was to compare the measured and predicted behavior of unbalanced laminates, including - in the case of the wing - a comparison between the behavior of the full scale structure and coupon tests. Both linear and nonlinear finite element (NASTRAN) analyses were carried out on the wing. Both linear and nonlinear point-stress analyses were performed on the coupons. All test articles were instrumented with strain gages, and wing deflections measured. The leading and trailing edges were found to have no effect on the response of the wing to applied loads. A decrease in the stiffness of the wing box was evident over the 27-test program. The measured load-strain behavior of the wing was found to be linear, in contrast to coupon tests of the same laminate, which were nonlinear. A linear NASTRAN analysis of the wing generally correlated more favorably with measurements than did a nonlinear analysis. An examination of the predicted deflections in the wing root region revealed an anomalous behavior of the structural model that cannot be explained. Both hysteresis and creep appear to be less significant in the wing tests than in the corresponding laminate coupon tests. Author

N89-18533# Oak Ridge National Lab., TN.
DAMAGE TOLERANCE EVALUATION OF PEEK (POLYETHER ETHER KENTONEL) COMPOSITES Final Report
J. L. FRAZIER Dec. 1988 190 p
(Contract DE-AC05-84OR-21400)
(DE89-005421; K/ETAC-61) Avail: NTIS HC A09/MF A01

A polyether ether kentone (PEEK) thermoplastic system is currently being evaluated in flight service as a structural element for the U.S. Air Force C-130 transport plane. The particular structure under study is the C-130 belly skin, a fuselage panel that is located on the underside of the aircraft and is subjected to impact from runway debris. A current Air Force objective is to reduce maintenance and replacement requirements of aircraft using lightweight composite structures to replace or supplement existing metal alloy components. The incorporation of lighter weight composite structures would result in aircraft weight reductions, allowing greater range and fuel economy. The impact-damage susceptibility of composite structures often results in strain-limited application of composite materials where the mechanical properties' advantages over traditional metal alloys are not attained. Methods developed to enhance the damage tolerance of composite material systems should increase their potential uses in existing and future aircraft. A materials evaluation program was conducted to determine the possible benefits of interleaving thermoplastic film layers between the plies of a PEEK/graphite composite material system to produce a material system with increased resistance to impact damage. DOE

N89-18546# Rolls-Royce Ltd., Derby (England).
REINFORCED TITANIUM FOR AERO-ENGINE APPLICATIONS
G. A. OWENS 10 May 1988 16 p Presented at the International Congress on Composite Materials, Milan, Italy, 10-12 May 1988
(PNR90476; ETN-89-93677) Avail: NTIS HC A03/MF A01

Continuous fiber reinforcement of titanium alloys to obtain improved performance and high temperature capability in aircraft engine compressors is discussed. Fiber technology requires large diameter fibers with protective surface compositions. The resulting large minimum bending ratio and brittle nature of the fibers impose considerable design and manufacturing limitations particularly for components of complex shape. ESA

N89-18550*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
MATE PROGRAM: EROSION RESISTANT COMPRESSOR AIRFOIL COATING, VOLUME 2 Final Report
MELVIN FRELING Mar. 1987 22 p
(Contract NAS3-20072)
(NASA-CR-179645; NAS 1.26:179645; PW-5574-212-VOL-2)
Avail: NTIS HC A03/MF A01 CSCL 11B

The performance of candidate erosion resistant airfoil coatings installed in ground tested experimental JT8D and JT9D engines and subjected to cyclic endurance at idle, takeoff and intermediate power conditions has been evaluated. Engine tests were terminated prior to the scheduled 1000 cycles of endurance test due to high cycle fatigue fracture of the Gator-Gard plasma sprayed 88WC-12Co coating on titanium alloy airfoils. Coated steel (AMS5616) and nickel base alloy (Incoloy 901) performed well in both engine tests. Post test airfoil analyses consisted of binocular, scanning electron microscope and metallographic examinations. Author

N89-19374# McDonnell Aircraft Co., Saint Louis, MO.
DURABILITY AND DAMAGE TOLERANCE OF BISMALEIMIDE COMPOSITES, VOLUME 1 Final Technical Report, 13 Sep. 1985 - 15 Jan. 1988
S. T. TYAHLA and PAUL S. MCCLELLAN, JR. Jun. 1988 168 p
(Contract F33615-85-C-3212)
(AD-A201273; AFWAL-TR-88-3026-VOL-1) Avail: NTIS HC A08/MF A01 CSCL 11D

The evaluation of durability and damage tolerance of bismaleimide (BMI) composites is presented. BMI resins have been developed for structural applications in 350F to 450F environments. This represents an improvement over epoxy resin capability of approximately 100F. In Task 1 of this program, we experimentally evaluated two second generation BMI systems (IM6/3100 and IM6/F650) and compared their performances with those of the baseline systems AS1/3501-6 and T300/V378A. The intermediate modulus fiber IM6 was chosen as the common fiber for both material systems because its high strength and stiffness are properties that are important for future fighter design. In Task 2, basic material properties were determined. The data included moisture absorption, glass transition temperature, thermal spike susceptibility, lamina properties, and interlaminar fracture toughness test results. Lamina properties and fracture toughness test data were used to correlate laminate behavior exhibited in Task 3. GRA

N89-19379# McDonnell Aircraft Co., Saint Louis, MO.
DURABILITY AND DAMAGE TOLERANCE OF BISMALEIMIDE COMPOSITES. VOLUME 2: APPENDIX OF CRACK GROWTH AND LOW-VELOCITY IMPACT DATA Final Technical Report, 13 Sep. 1985 - 15 Jan. 1988
S. T. TYAHLA and PAUL S. MCCLELLAN, JR. Jun. 1988 242 p
(Contract F33615-85-C-3212)
(AD-A201839; AFWAL-TR-88-3026-VOL-2) Avail: NTIS HC A11/MF A01 CSCL 11D

This program was the evaluation of durability and damage tolerance of bismaleimide (BMI) composites. BMI resins have been developed for structural applications in 350 F to 450 F environments. The represents an improvement over epoxy resin capability of approximately 100 F. In Task 1 of this program we experimentally evaluated two second generation BMI systems (IM6/3100 and IM6/F650) and compared their performance with that of baseline systems AS1/3501-6 and T300/V378A. The intermediate modulus fiber IM6 was chosen as the common fiber for both material systems because its high strength and stiffness are properties that are important for future fighter design. In Task II basic material properties were determined. The data included moisture absorption, glass transition temperature, thermal spike susceptibility, lamina properties, and interlaminar fracture toughness test results. Lamina properties and fracture toughness test data were used to correlate laminate behavior exhibited in Task III. GRA

N89-19392# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
FLAME DRIVING OF LONGITUDINAL INSTABILITIES IN LIQUID FUELED DUMP COMBUSTORS Final Report, 1 Jul. 1984 - 29 Feb. 1988
BEN T. ZINN, UDAY G. HEGDE, DIERK REUTER, and B. R. DANIEL 1 Oct. 1988 126 p
(Contract N00014-84-K-0470)
(AD-A201293) Avail: NTIS HC A07/MF A01 CSCL 21E

This report describes the results of experimental and theoretical investigations of the mechanisms by which the core flow combustion process in coaxial, single inlet, dump type ramjet engines drives longitudinal combustion instabilities. To this end, the behavior of V-shaped flames, similar to those often occurring in ramjet combustors, stabilized in longitudinal acoustic fields has been studied. The presence of burning vortical structures is observed in the flame region. These structures appear at frequencies close to the first natural acoustic frequency of the combustor and are believed to be connected with a shear layer type of instability of the flame. Experiments conducted show that the unsteady combustion in these structures is capable of driving the acoustics at the fundamental acoustic mode frequency. With increase in fuel air ratio, a spontaneous instability involving the fundamental mode is observed and explained in terms of increased driving associated with the higher, unsteady heat release rates. GRA

N89-19413# Rolls-Royce Ltd., Derby (England).
MICROSTRUCTURAL OPTIMISATION OF TITANIUM ALLOYS FOR DEFECT TOLERANCE IN GAS TURBINE ENGINE COMPONENTS
M. T. COPE, P. J. POSTANS, and M. A. HICKS 15 Feb. 1987 9 p Presented at the TMS-AIME Meeting on Effect of Microstructures on Fracture Toughness and Fatigue Crack Growth Rate in Titanium Alloys, Denver, CO, Feb. 1987 Previously announced in IAA as A89-10069
(PNR90503; ETN-89-93347) Avail: NTIS HC A02/MF A01

Results for aligned and basketweave microstructures in near alpha alloys used on gas turbine engines are presented together with observations titanium alloy. To minimize crack propagation rates, it is important to minimize the prior beta grain size and the level of alpha platelet alignment. The propagation rate depends on the propagation mode which depends on the orientation of the structure presented to the crack tip. ESA

N89-19441# Southwest Research Inst., San Antonio, TX. Fuels and Lubricants Research Div.
APPLICATION OF NONDESTRUCTIVE EVALUATIONS TO THE PREDICTION OF TURBINE FUEL PEROXIDATION POTENTIAL Final Report, 5 Aug. 1987 - 5 Feb. 1988
G. E. FODOR, K. B. KOHL, and D. W. NAEGELI Feb. 1988 17 p
(Contract DLA900-84-C-0910)
(AD-A202291; SWRI-17-7958-840) Avail: NTIS HC A03/MF A01 CSCL 21D

After the theoretical and experimental baselines were established to determine the potential peroxide content of jet fuels, nondestructive methods of analyses were evaluated to augment the procedures. The use of proton Nuclear Magnetic Resonance (NMR), ultraviolet (UV), and infrared (IR) spectroscopies were evaluated. UV and NMR did not respond to the trace-quantity compositional changes caused by autoxidation in the examined fuels. Direct detection and measurement of the primary autoxidation intermediates, that is, peroxides and hydroperoxides, were not feasible by the applied nondestructive analytical methods. Indications are that IR may be used for the detection and measurement of peroxide decomposition products such as alcohols and carbonyl compounds. GRA

12

ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A89-28849
MOTION-INDUCED UNSTEADY AIRLOADS ON AN OSCILLATING LOW-ASPECT-RATIO TRAPEZOIDAL HALF-WING IN SEPARATED FLOW
H. FOERSCHING and H. ZINGEL (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Journal of Fluids and Structures (ISSN 0889-9746), vol. 2, Nov. 1988, p. 515-539. refs

The pitch and roll response of a harmonically oscillating low-aspect-ratio trapezoidal half-wing in separated flow is investigated experimentally in the DFVLR Goettingen 3 x 3-m low-speed wind tunnel at incidence angles up to 40 deg and Reynolds number 2.4 x 10 to the 6th. The experimental setup and procedures are described, and the results are compared with theoretical predictions in extensive graphs and characterized in detail. Particular attention is given to the incorporation of the unsteady-airload data into semiempirical forced-oscillation models of buffeting, flutter, and entrainment phenomena. It is demonstrated that superposition models based on linearized small-perturbation theory cannot account for the effects of the steady flowfield on the motion-induced unsteady airloads. T.K.

A89-29102#
PERTURBATION EVALUATION OF DYNAMIC BEHAVIOR OF A CLASS OF ELASTIC VEHICLES
SHUO TANG and SHILU CHEN (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 7, Jan. 1989, p. 11-20. In Chinese, with abstract in English. refs

A new mathematical tool called perturbation and evaluation theory for matrix eigenvalue is used to analyze the influence of unsteady aerodynamics on the dynamic behavior of slender flight vehicle systems. The first-order perturbation solutions of system eigenvalues and the upper and lower bounds of the approximation error are obtained. Numerical calculations show that the method is accurate and effective for estimating the dynamic behavior of the elastic vehicle system from the vehicle model considering only quasi-steady aerodynamic force under certain conditions. The relative error of the perturbation solution with respect to the accurate solution is less than 10 percent. C.D.

A89-29104#
FRACTURE BEHAVIOR OF ADHESIVELY REPAIRED CRACKED PLATE
SIYI CHEN, ZHIXIAN LU, and SITAO ZHENG (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 7, Jan. 1989, p. 29-38. In Chinese, with abstract in English. refs

Experiments using metal bonded patches for repair of cracked aircraft structures are reported which overcome the expense and labor problems of the method of Jones (1984). The present method increases the load-carrying capacity of patched plate by 50-90 percent, thus delaying catastrophic failure. The increase in load-carrying capacity is the same or a little greater than that in the Jones method. C.D.

A89-29106#
3-D FINITE ELEMENT VIBRATION ANALYSIS OF HELICAL GEARS
GENG LIU, ZHENDONG HUANG, and DAWEI HE (Northwestern Polytechnical University, Xian, People's Republic of China) Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 7, Jan. 1989, p. 47-55. In Chinese, with abstract in English. refs

The vibration of helical gear structure is theoretically studied. Three-dimensional models which take the flexibility of the gear structure into account are used. The calculations can be performed with a microcomputer and require relatively little CPU time and relatively limited computer memory. Rational rim and web sizes for helical gears with different web arrangements are recommended for improving the vibration characteristics of helical gears. C.D.

A89-29125
NON-DESTRUCTIVE TESTING
BARRY HULL (Sheffield City Polytechnic, England) and VERNON JOHN (Central London, Polytechnic, London, England) New York, Springer-Verlag, New York, Inc., 1988, 159 p. refs

Theoretical and practical aspects of industrial NDE are examined in an introduction for engineering students. Topics addressed include liquid-penetrant inspection, magnetic-particle inspection, eddy-current methods, ultrasonic testing, and radiography. Consideration is given to optical inspection probes, neutron radiography, laser-induced ultrasonics, time-of-flight diffraction, AE methods, crack-depth gages, thermography, surface-texture analysis, and multiphase flow analysis. Extensive diagrams, graphs, and photographs are provided. T.K.

A89-29231#
IMPROVEMENTS TO THE VISUALIZATION TECHNIQUES EMPLOYED IN THE ONERA HYDRODYNAMIC TUNNELS FOR THE QUANTITATIVE STUDY OF STEADY FLOWS [AMELIORATIONS APPORTEES AUX PROCEDES DE VISUALISATIONS DES ECOULEMENTS STATIONNAIRES DANS LES TUNNELS HYDRODYNAMIQUES DE L'ONERA EN VUE DE LEUR EXPLOITATION QUANTITATIVE]
M. GALLON (ONERA, Chatillon-sous-Bagneux, France) (Colloque National de Visualisations et de Traitement d'Images, 3rd, Belfort, France, May 18-20, 1988) ONERA, TP, no. 1988-53, 1988, 8 p. In French.
(ONERA, TP NO. 1988-53)

Classical hydrogen-bubble electrolysis is employed as a visualization technique in the ONERA hydrodynamic wind tunnel in order to quantitatively study steady flows. Results are presented for a NACA 0012 profile, a two-dimensional air inlet, and a thin delta wing. The present method makes possible the visualization of time lines and regularly-spaced flow lines. The results are compared with those obtained by a liquid-tracer technique. R.R.

A89-29239#
DRAG PREDICTION USING STATE-OF-THE-ART CALCULATION METHODS IN FRANCE [PREVISION DE LA TRAINEE A PARTIR DES METHODES DE CALCUL ETAT DE L'ART EN FRANCE]
J. J. THIBERT (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Meeting, Lisbon, Portugal, May 2-5, 1988) ONERA, TP, no. 1988-74, 1988, 12 p. In French. refs
(ONERA TP, NO. 1988-74)

Various two-dimensional and three-dimensional inviscid-flow methods for drag component analysis are presented which are based on solving either the potential equation or the Euler equations. Comparison with experimental results demonstrates that coupled methods can predict drag to within a few percent. It is suggested that the pressure term should be replaced in the two-dimensional case by the shock drag term and in the three-dimensional case by the sum of the induced drag and the shock drag. R.R.

A89-29279#

EFFICIENT SOLUTION OF THE STEADY EULER EQUATIONS WITH A CENTERED IMPLICIT METHOD

A. LERAT (Ecole Nationale Superieure d'Arts et Metiers, Paris, France) and J. SIDES (ONERA, Chatillon-sous-Bagneux, France) (International Conference on Numerical Methods for Fluid Dynamics, Oxford, England, Mar. 21-24, 1988) ONERA, TP, no. 1988-128, 1988, 22 p. refs
(ONERA, TP NO. 1988-128)

A centered Euler solver based on an implicit method of second-order accuracy is described. Consideration is given to various applications to transonic aerodynamics, including the internal flow in a channel with a bump and several external flows over an airfoil at low and high angles of attack. The efficiency and shock-capturing capabilities of the method are demonstrated. K.K.

A89-29464

A REFINED BEAM THEORY FOR ADVANCED COMPOSITE ROTOR BLADE ANALYSIS

J. B. KOSMATKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 29 p. Research supported by TRW, Inc. refs
(Contract NSF MSM-88-09132)

An analytical model is presented for accurately determining the three-dimensional response and stress distribution (including interlaminar shear) of advanced composite helicopter rotor blades. This model is developed by formulating Saint-Venant's elasticity solutions for the extension, bending, torsion, and flexure of a prismatic beam whose cross section is nonhomogeneous and generally anisotropic. The coupled second order elasticity problem is solved based upon the principle of minimum potential energy and a two-dimensional finite element approach. Derivations are also included for calculating the one-dimensional beam-theory properties; the beam twist, Saint-Venant torsion warping distribution, torsion constant, flexural center, moment-curvature relations, and shear correction factors. Numerical results are presented to illustrate the versatility of this model by analyzing both isotropic and advanced composite airfoil sections. Author

A89-29467

DEVELOPMENT OF AN INTEGRAL COMPOSITE DRIVE SHAFT AND COUPLING

HOWARD S. FAUST, EDWARD M. HOGAN, RAVI N. MARGASAHAYAM (Boeing Helicopters, Philadelphia, PA), and JOSEPH HESS (Bentley-Harris Manufacturing Co., Lionville, PA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. Research supported by the Bentley-Harris Manufacturing Co. refs
(Contract DAAJ02-87-C-0005)

The status of development of a one-piece composite drive shaft for the engine-to-transmission connection is described. This shaft features braided-fiberglass construction with integrally fabricated flexible couplings. Driving design parameters, material selection, fabrication, tests of subscale shafts, and finite-element analysis are discussed. Planned testing of full-scale shafts is described. Author

A89-29468

DEMONSTRATION OF A SUPERCRITICAL COMPOSITE HELICOPTER POWER TRANSMISSION SHAFT

P. L. JONES, R. F. KRAUS, and M. S. DARLOW (Rensselaer Polytechnic Institute, Troy, NY) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. refs
(Contract DAAG29-82-K-0093)

An experimental program is underway to investigate the dynamic behavior of supercritical composite drive shafts for helicopter applications. Design optimization results have shown that the system of least weight is achieved by incorporating supercritical operation and advanced composite materials. Uncertainties in the ability to manufacture, balance and safely operate supercritical composite shafts motivates the experimental program to examine their dynamic performance. Results for experiments with an aluminum and an optimized graphite/epoxy shaft are presented. Due to the relatively low bending stiffness of the optimized shaft, the critical speed behavior of the shaft is of great importance and is discussed in detail. Author

A89-29469

MCDONNELL AIRCRAFT COMPOSITES MANUFACTURING - EXPERIENCING GROWTH

BARTON W. MOENSTER (McDonnell Aircraft Co., Saint Louis, MO) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 16 p.

A development history and prospective developments projection is presented for proprietary efforts toward the incorporation of high-performance polymer-matrix composites in fighter aircraft. These aircraft have been, in historical sequence and order of increasing composites incorporation, the F-4, F-15, F/A-18, and AV-8B Harrier II. Technology development milestones are associated with the NC automation of composite ply layup processes employing knives and lasers for reinforcement cutting, nesting systems, and core carving machines. Innovative tooling development has allowed complex cocured assemblies to be built. O.C.

A89-29471* Douglas Aircraft Co., Inc., Long Beach, CA.

LOW COST DAMAGE TOLERANT COMPOSITE FABRICATION

R. J. PALMER (Douglas Aircraft Co., Long Beach, CA) and W. T. FREEMAN (NASA, Langley Research Center, Hampton, VA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 15 p.

The resin transfer molding (RTM) process applied to composite aircraft parts offers the potential for using low cost resin systems with dry graphite fabrics that can be significantly less expensive than prepreg tape fabricated components. Stitched graphite fabric composites have demonstrated compression after impact failure performance that equals or exceeds that of thermoplastic or tough thermoset matrix composites. This paper reviews methods developed to fabricate complex shape composite parts using stitched graphite fabrics to increase damage tolerance with RTM processes to reduce fabrication cost. Author

A89-29473

U.S. ARMY REQUIREMENTS FOR FATIGUE INTEGRITY

ROBERT W. ARDEN and FREDERICK H. IMMEN (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 11 p. refs

The present discussion of current U.S. Army structural reliability analysis practices gives attention to their applicability to fatigue life evaluation and to the definition of typical methodological variations' impact on overall component reliability results. It is recommended that helicopter manufacturers standardize the parameters of the fatigue strength curve, in order to improve not only reliability analyses but also basic fatigue calculations; in addition, flight recorders must be used to establish an accurate helicopter usage spectrum in place of current, highly subjective pilot reports. O.C.

A89-29474
NASTRAN MODELLING OF HONEYCOMB SANDWICH PANELS SUBJECTED TO PICTURE FRAME SHEAR
ANDREW N. BERTOLAZZI (Boeing Helicopters, Philadelphia, PA) IN: National Technical Specialists' Meeting on Advanced Rotorcraft Structures, Williamsburg, VA, Oct. 25-27, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 7 p. refs

The modeling of honeycomb sandwich panels subjected to in-plane shear loading is presently accomplished by incorporating a detailed model of the 'picture frame' fixture used to generate the loading. This model encompasses external boundary conditions and forces as well as the panel-attachment bolts. The model was compared to experimental results from the subjection of composite sandwich panels to in-plane shear loading representative of a B 360 helicopter's fuselage structure, which employs panels with woven composite facesheets or woven kevlar facesheets over a nomex honeycomb core. Generally good agreement between model and experiment data is obtained. O.C.

A89-29509
THERMOGRAPHIC INSPECTION OF SUPERPLASTICALLY FORMED DIFFUSION BONDED TITANIUM PANELS
DAVID L. HAAVIG and DANIEL C. KING (McDonnell Douglas Corp., Saint Louis, MO) IN: Thermal infrared sensing for diagnostics and control (Thermosense X); Proceedings of the Meeting, Orlando, FL, Apr. 5-8, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 102-110.

The feasibility of using IR thermograms to detect unbonded regions of two- or four-sheet Ti-alloy panels fabricated by the SPF/DB process is investigated experimentally. The basic steps of the manufacturing process are reviewed; the principles and performance of current ultrasonic NDT methods are described; and results obtained with a prototype thermographic system (based on a scanning IR camera with an HgCdTe detector operating at 3-12 microns with dynamic temperature range about 35 F) are presented graphically. The system is shown to resolve objects as small as 0.1 inches and to detect all of the faults found with ultrasonic NDT; the IR NDT method, however, offers significant savings in time. T.K.

A89-29755
APPLICATION OF THE TIME-DOMAIN FINITE DIFFERENCE METHOD TO THE DETERMINATION OF ELECTROMAGNETIC FIELDS PENETRATING A CAVITY VIA AN APERTURE [APPLICATION DE LA METHODE DE RESOLUTION PAR DIFFERENCES FINIES EN REGIME TRANSITOIRE A LA DETERMINATION DES CHAMPS ELECTROMAGNETIQUES PENETRANT DANS UNE CAVITE VIA UNE OUVERTURE]
ALAIN REINEIX, BERNARD JECKO (Limoges, Universite, France), and PATRICK BREUILH (Gramat, Centre d'Etudes, France) Annales des Telecommunications (ISSN 0003-4347), vol. 43, Nov.-Dec. 1988, p. 695-702. In French. Research supported by the Centre d'Etudes de Gramat. refs

A time-domain finite difference method has been developed to measure the electromagnetic field entering a cavity through a large opening, and results are presented for the examples of a model plane and a hanger in an aircraft carrier. In the present technique, the classical method is modified by the introduction of Huygens sources at the location of the aperture. The method is shown to reduce the large storage requirements of the classical method and to make the internal fields more stable. R.R.

A89-29977* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IN SITU COMPOSITE CURE MONITORING USING INFRARED TRANSMITTING OPTICAL FIBERS
PHILIP R. YOUNG (NASA, Langley Research Center, Hampton, VA), MARK A. DRUY (Foster-Miller, Inc., Waltham, MA), W. A. STEVENSON (IRIS Fiber Optics, Inc., Acton, MA), and DAVID A. C. COMPTON (Biorad Laboratories, Cambridge, MA) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 336-347. refs
(Contract NAS1-18659)

The development of infrared-transmitting optical fibers as sensors for monitoring the cure of advanced composite materials is reported. Fourier transform infrared spectra are presented which were remotely sensed during the cure of a high performance polyimide resin and a graphite/polyimide matrix prepreg using an 0.1 mm O.D. x 3 m chalcogenide optical fiber. A discussion of the fiber and sensor element, absorption mechanism and potential applications is presented. Author

A89-29984
GC - A MEASURE OF DAMAGE TOLERANCE OF COMPOSITES
RAM C. MADAN (Douglas Aircraft Co., Long Beach, CA) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 403-413. refs

The approach described here relates the parameters which define the toughness of the composite to Gc - strain energy release rate. This paper summarizes techniques to determine delamination of composites under various static and dynamic loading. Further, all toughness characteristics are correlated with Gc. Methods of improving Gc are outlined in terms of the composites' properties. Finally, delamination control techniques are summarized for damage tolerance of composites. The graphic approach is used to derive the relations for Gc to determine delamination growth and low-velocity impact damage areas for different composite materials. Author

A89-29993
AUTOMATED EDDY CURRENT TESTING OF COMPOSITES
A. MAHOON (British Aerospace, PLC, Kingston-upon-Thames, England) IN: Materials - Processes: The intercept point; Proceedings of the Twentieth International SAMPE Technical Conference, Minneapolis, MN, Sept. 27-29, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 517-523. refs

The paper describes an automatic eddy-current test procedure for composites and the presentation of test data in the form of facsimile C-scan traces. It is shown that the test control parameters such as speed of scanning, lift-off variation, and the eddy-current operating frequency influence the resolution of defect detection. Automated eddy-current testing is capable of detecting interply delaminations and cracking due to impact and fatigue damage. The technique is also able to detect deep translaminar cracks, film inclusions, and resin/fiber-ratio variations. The technique is unable to detect water ingress and void-content variations. Author

A89-30178
UNSTEADY LOADS ON A WEDGE DURING THE DIFFRACTION OF A SHOCK WAVE MOVING AT ANGLE OF ATTACK [NESTATSIONARNYE NAGRUZKI NA KLIN PRI DIFRAKTSII UDARNOI VOLNY, DVIZHUSHCHEISIA POD UGLOM ATAKI]
A. G. CHERNOV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Nov.-Dec. 1988, p. 70-73. In Russian. refs

A89-30182
IMPROVEMENT OF THE COMPLEX NONDESTRUCTIVE TESTING OF CALORIZED TURBINE BLADES [RATSIONALIZATSIIA KOMPLEKSNOGO NERAZRUSHAIUSHCHEGO KONTROLIA ALITIRUEMYKH LOPATOK TURBIN]
IU. A. GLAZKOV Defektoskopiia (ISSN 0130-3082), no. 1, 1989, p. 47-50. In Russian. refs

A study is made of the effect of the fused-slurry calorizing of turbine blades during engine rebuilding on the results of capillary (luminescent or chromatic) and eddy current testing. These methods are found to be incapable of detecting cracks up to 15 mm long in the base metal of the blades. In order to ensure the detection of these cracks, testing prior to the calorizing treatment is essential. V.L.

A89-30206

AN EXPERIMENTAL STUDY OF THE FORMATION AND EVOLUTION OF TWO-DIMENSIONAL WAVE PACKETS IN A BOUNDARY LAYER [EKSPERIMENTAL'NOE ISSLEDOVANIE VOZNIKNOVENIIA I RAZVITIIA DVUMERNYKH VOLNOVYKH PAKETOV V POGRANICHNOM SLOE]

G. R. GREK, V. V. KOZLOV, and M. P. RAMAZANOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Dec. 1988, p. 24-30. In Russian. refs

Experiments have been carried out in a subsonic wind tunnel to investigate the formation of two-dimensional wave packets in the vicinity of a perturbation source before the onset of the proper perturbations of the boundary layer. It is shown that the velocity of perturbation fronts propagating downstream decreases abruptly and stabilizes at a certain level. The region of the spatial evolution of the two-dimensional wave packets is investigated, and it is shown that the propagation velocities of the leading and trailing fronts of the packets in the longitudinal direction remain constant and are 0.43 and 0.30 of the mean velocity, respectively. V.L.

A89-30210

AERODYNAMICS AND HEAT TRANSFER OF A SWIRLING FLOW ON THE END SURFACE OF A VORTEX CHAMBER [AERODINAMIKA I TEPLOOBMEN ZAKRUCHENNOGO POTOKA NA TORTSEVOI POVERKHNOSTI VIKHREVOI KAMERY]

A. A. KHALATOV and I. M. ZAGUMENNOV (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Dec. 1988, p. 134-140. In Russian. refs

The aerodynamic and heat transfer characteristics of a swirling flow on the end surface of a vortex chamber are investigated experimentally. Based on the results of the study, relations are obtained for calculating the local and integral characteristics of the flow. It is shown, in particular, that experimentally determined friction and heat transfer in a developing flow are on the average 40 percent lower than in a fully developed flow. V.L.

A89-30254

JET FLOWS OF REACTING GASES [STRUINYE TECHENIIA REAGIRUIUSHCHIKH GAZOV]

FARKHADZHAN ALIEV and ZAIR SH. ZHUMAEV Tashkent, Izdatel'stvo Fan, 1987, 132 p. In Russian. refs

The book presents fundamentals of the aerodynamic theory and calculation of straight gas jets. The discussion focuses on the flow structure and turbulent combustion of unmixed gases and thermal characteristics of the jet. The following three types of problems are considered: motion of unmixed chemically active gases; gas motion under conditions of chemical equilibrium; and motion of gases under conditions of finite-rate chemical reactions. V.L.

A89-30499*# Old Dominion Univ., Norfolk, VA.

TEMPORAL STABILITY OF MULTIPLE-CELL VORTICES

M. R. KHORRAMI and C. E. GROSCH (Old Dominion University, Norfolk, VA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 8 p. refs

(Contract NAG1-530)

(AIAA PAPER 89-0987)

The temporal stability of multiple cell vortices is studied with a staggered Chebyshev spectral collocation technique. It is shown that cell multiplicity in the vortex core has a drastic effect on the stability characteristics. While validating the spectral collocation algorithm, two new viscous modes of instability for Batchelor's (1964) vortex were found. These modes are discussed in detail. Author

A89-30505#

SHEAR FLOW CONTROL BY MECHANICAL TABS

K. K. AHUJA and W. H. BROWN (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 8 p. Research supported by the Lockheed Internal Research and Development Program. refs

(AIAA PAPER 89-0994)

This paper discusses results of an experimental study on jet-mixing enhancement of heated and unheated, subsonic and underexpanded supersonic model jets by mechanical protuberances (tabs) located at the nozzle lip. It is shown that considerable mixing enhancement is obtained by these devices. Relative performance of two, three, and four tabs is also evaluated. It is found that the best overall effect is produced by two tabs located diametrically opposite to each other. Limited temperature measurements indicate considerable reduction in the plume temperature. Likewise, it is found that the screech noise associated with supersonic underexpanded jets can be reduced and in many cases completely eliminated. Author

A89-30522*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

LEBU DRAG REDUCTION IN HIGH REYNOLDS NUMBER BOUNDARY LAYERS

J. B. ANDERS (NASA, Langley Research Center, Hampton, VA) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 11 p. refs

(AIAA PAPER 89-1011)

Conventional and inverted, outer-layer leading-edge breakup devices (LEBUs) were water tunnel tested on an axisymmetric body over the Re number range from 380,000 to 3.8 million. Test results indicate a sharp degradation of the LEBUs' drag-reduction mechanism with increasing Re number. The most likely result of this degradation is a decoupling of the inner and outer scales at higher Re numbers; due to this decoupling, the breakup of the large structures by outer-layer devices has minimal influence on the near-wall, shear-producing scales. This suggests that smaller devices, closer to the walls, may be required for operation at elevated Re numbers. O.C.

A89-30525#

CONTROL OF SEPARATION IN DIFFUSERS USING FORCED UNSTEADINESS

DIN CHEN and ZHANG SHIYING (Nanjing Aeronautical Institute, People's Republic of China) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 9 p. refs

(AIAA PAPER 89-1015)

The flow in a two-dimensional diffuser was experimentally studied, varying the location of the separated flow using forced unsteadiness. Without outside perturbation, the diffuser flow usually separated at one side of the channel. Unsteadiness introduced by a spoiler-like flap mounted on the opposite wall is shown to reduce the size of the separated zone and improve the performance of the diffuser. R.R.

A89-30527#

SIGNATURES OF UNSTEADY SEPARATION

M. ANWAR RAMIZ and MUKUND ACHARYA (Illinois Institute of Technology, Chicago) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 11 p. refs

(Contract F49620-86-C-0133)

(AIAA PAPER 89-1017)

The unsteady separation introduced in a boundary layer by the motion of a spanwise flap was studied using smoke-wire flow visualizations, measurements of the time-varying flow direction at various locations behind the flap, and wall pressure data. Flow criteria for flow state identification were developed which can determine whether the flow over the wall is attached or separated at any time instant. Results are obtained for collapsing separations resulting from the flap moving back into the wall, as well as for combined ring and falling flap motions. R.R.

A89-30528*# Cincinnati Univ., OH.
ANALYSIS AND CONTROL OF UNSTEADY SEPARATED FLOWS
U. GHIA, L. ZUO, and K. N. GHIA (Cincinnati, University, OH) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 10 p. Research supported by McDonnell Douglas Corp. refs
(Contract AF-AFOSR-85-0231; AF-AFOSR-87-0074; NAG1-753)
(AIAA PAPER 89-1018)
The active control of unsteady separated flows is considered, and the development of the separated flow following the formation and shedding of the starting vortex is characterized. In the method, the Navier-Stokes equations are formulated in time-dependent general orthogonal coordinates which remain boundary aligned for arbitrary boundary deformations. Results obtained for a backstep-channel flow with an oscillating flap demonstrate the effectiveness of the flap as a control mechanism. R.R.

A89-30532#
CORRELATION OF OUTER AND PASSIVE WALL REGION MANIPULATION WITH BOUNDARY LAYER COHERENT STRUCTURE DYNAMICS AND SUGGESTIONS FOR IMPROVED DEVICES
R. E. FALCO (Michigan State University, East Lansing) AIAA, Shear Flow Conference, 2nd, Tempe, AZ, Mar. 13-16, 1989. 14 p. Research supported by USAF. refs
(AIAA PAPER 89-1026)
The interaction of coherent structures found in turbulent boundary layers with outer layer plate/airfoil manipulators, and the interaction of wall region coherent structure with riblets is discussed. Local flow conditions on outer layer manipulators are shown to be sensitive to the instantaneous angle of attack of the flow, which is a function of the structure of the large scale motions within the turbulent boundary layer. It is shown that the time signature of these motions is highly skewed resulting in more severe separation on the wallward side of the device. The larger separation results in more device drag and in the creation of a wake that spreads more rapidly intersecting the wall more quickly. This decreases the local Cf reduction. Recent understanding of turbulent wall structure and how riblets interfere with it is also discussed. Optimization of these manipulators is suggested in the light of this structural viewpoint. New ways to interfere with coherent structures are discussed. Author

A89-30555
ANALYSIS OF A MODIFIED FREE-EDGE DELAMINATION SPECIMEN
HOWARD W. BROWN (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: American Society for Composites, Technical Conference, 3rd, Seattle, WA, Sept. 25-29, 1988, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1988, p. 61-70. refs
A sublaminate modeling technique derived from laminated plate theory is presently used to calculate the approximate energy release rate of a modified free-edge delamination specimen, where the sublaminate-displacement equations are written in cells that are used in assembling the displacement equations for the laminate. Boundary and continuity conditions consistent with those derived from variational methods are assembled using laminate layup, and sublaminate boundary conditions are used to solve for the displacements and intersublaminate stresses of specimens undergoing generalized plane strain. O.C.

A89-30616#
VIBRATION ISOLATION OF A SYSTEM - A POWERPLANT ON A MOVING OBJECT
MARIAN JEZ (Instytut Lotnictwa, Warsaw, Poland) Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 110-111, 1987, p. 3-104. In Polish. refs
Ways of reducing vibrations in systems consisting of a moving object carrying a powerplant are examined with allowance for the kinematic and dynamic forces generated by both components of the system. A model for a system of this kind is developed and identified using two light planes as examples. Equations describing the motion of the system are obtained and solved by the Runge-Kutta method. An empirical method for selecting the suspension is proposed which is based on acceleration measurements and on statistical and correlation analyses of vibration signals at selected points of the system. V.L.

A89-30651
AIAA, ASME, ASCE, AHS, AND ASC, STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 30TH, MOBILE, AL, APR. 3-5, 1989, TECHNICAL PAPERS. PARTS 1, 2, 3, & 4
Conference sponsored by AIAA, ASME, ASCE, AHS, and ASC. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. Pt. 1, 593 p.; pt. 2, 529 p.; pt. 3, 500 p.; pt. 4, 721 p. For individual items see A89-30652 to A89-30891.
Recent analytical and experimental investigations of structural dynamics and material behavior in aerospace applications are discussed in reviews and reports. Topics addressed include panel flutter, active control, the buckling of composite structures, FEM techniques, optimization methods, the vibration of cyclic structures, composites and laminated plates and shells, aeroelasticity, dynamics and damping, nonlinear vibrations, dynamic stability, and control and synthesis. Consideration is given to thermal structures, rotor elasticity, structural-system identification, damage/failure analysis and testing of composites, dynamic modeling, aerodynamic loading, adaptive structures, modal testing and correlation, buckling and postbuckling, space structures, acoustics and random vibration, probabilistic methods, eigenvector solution methods, impact analysis, and the accuracy of FEM solutions. T.K.

A89-30658#
AXISYMMETRIC PANEL FLUTTER OF RING-REINFORCED COMPOSITE CYLINDRICAL SHELLS
VICTOR BIRMAN (Missouri-Rolla, University, Rolla) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 62-67. refs
(AIAA PAPER 89-1167)
The axisymmetric aerodynamic problem of composite cylindrical shells reinforced by internal stiffeners is considered. The shells are subject to the simultaneous action of a supersonic gas flow, thermal field and axial load. First, governing equations are formulated and the interaction between the loads in both static and dynamic, linear and nonlinear problems is discussed. The linear flutter problem is then studied both for discrete stiffeners as well as for the case of smeared out rings. Closed form analytical expressions for the flutter velocity parameter are obtained by assumption that the motion components can be represented by two-term series. Author

A89-30669#
USE OF SECOND ORDER CFD GENERATED GLOBAL SENSITIVITY DERIVATIVES FOR COUPLED PROBLEMS
H. IDE and M. LEVINE (Rockwell International Corp., Los Angeles, CA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 176-182. Research supported by Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 89-1178)
The application of second-order sensitivity derivatives obtained with CFD algorithms to first-order coupled aerodynamic/control/structural optimization problems is described and demonstrated by means of trial computations. The nature of the coupled problem is explored; the mathematical formulation is outlined; and the capabilities of state-of-the-art CFD codes are reviewed. Results for a low-aspect-ratio wing model at freestream Mach number 0.9, angle of attack 0 deg, and dynamic pressure 1.054 psi are presented in extensive graphs and discussed in detail. The three-dimensional full-potential aeroelastic/control code employed (Ide and Shankar, 1987) is shown to significantly improve

the efficiency of the optimization procedure, automatically combining aerodynamic, control, and structural information to provide derivatives equivalent to Sobielski global-sensitivity derivatives. T.K.

A89-30675#

LIMIT CYCLE PHENOMENA IN COMPUTATIONAL TRANSONIC AEROELASTICITY

KENNETH A. KOUSEN (United Technologies Research Center, East Hartford, CT) and ODDVAR O. BENDIKSEN (California, University, Los Angeles) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 230-240. refs
(AIAA PAPER 89-1185)

Using a two degree-of-freedom typical section model coupled to an unsteady Euler equations solver, limit cycle behavior has been observed in the past by Kousen and Bendiksen (1988). In the present paper, the structural nonlinearity of freeplay has been added to the typical section model, and its effects on the dynamic stability problem are assessed. In addition, limit cycle behavior in the swept wing model of Isogai is demonstrated and related to the observed presence of multiple flutter points in the transonic regime in this problem. Author

A89-30686#

PASSIVE AND ACTIVE DAMPING AUGMENTATION SYSTEMS IN THE FIELDS OF STRUCTURAL DYNAMICS AND ACOUSTICS

RAYMOND FREYMANN (BMW AG, Munich, Federal Republic of Germany) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 348-361. refs
(AIAA PAPER 89-1196)

It is shown how far damping augmentation is beneficial to the dynamic response behavior of multidegree-of-freedom vibrational systems. Passive and active damping augmentation systems are considered. Thereby focus is pointed especially on the alleviation of the dynamic response in so-called 'critical' eigenmodes. Practical applications taken from the fields of structural dynamics and acoustics are presented. Author

A89-30741#

RELIABILITY ANALYSIS OF THE VIRKLER FATIGUE CRACK GROWTH DATA

J. TANG, T. J. ENNEKING, and B. F. SPENCER, JR. (Notre Dame, University, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 837-844. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 89-1256)

A two-state stochastic model for fatigue crack growth problems is presented and solutions are given which will, for the first time, directly provide the distribution of the random time to reach a critical crack size. An extensive fatigue crack growth data set, known as the Virkler data, is employed to verify the model. Equations in terms of the variance and skewness of the random time to reach a critical crack size are formed directly. A detailed description of the procedure used for parameter estimation is also provided. Author

A89-30831*# Analytical Services and Materials, Inc., Hampton, VA.

EFFECTS OF TRANSVERSE SHEAR ON LARGE DEFLECTION RANDOM RESPONSE OF SYMMETRIC COMPOSITE LAMINATES WITH MIXED BOUNDARY CONDITIONS

C. B. PRASAD (Analytical Services and Materials, Inc., Hampton, VA) and CHUH MEI (Old Dominion University, Norfolk, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1716-1733. refs
(Contract NAG1-838)
(AIAA PAPER 89-1356)

Nonlinear equations of motion of symmetrically laminated anisotropic plates are derived considering von Karman strains and transverse shear effects. Using a single-mode Galerkin procedure, the nonlinear modal equation is obtained. The direct equivalent linearization method is employed for solution of this equation. The effects of transverse shear on large deflection vibration of laminated plates with mixed boundary support conditions under random excitation are studied. Mean-square deflections and mean-square inplane strains are obtained for symmetric graphite-epoxy laminates. Using equilibrium equations and the continuity requirements, the mean-square transverse shear stresses are calculated. The results obtained will be useful in the sonic fatigue design of composite aircraft panels. The analysis is presented in detail for plates with two opposing edges simply supported and the remaining edges clamped. Author

A89-30835#

COMPONENT-LEVEL ANALYSIS OF COMPOSITE BOX BEAMS

ERIC C. KLANG (North Carolina State University, Raleigh) and T. M. KUO IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1765-1771. refs
(AIAA PAPER 89-1360)

The present analysis has studied the deformation of a composite box beam under various loads. The mathematical model used throughout this study consists of the Ritz method coupled with laminated plate theory. It was found that the joint stiffness at the corners of the box beam has an important influence on the overall performance of the box beam. The laminate stacking sequence also plays an important role in the deformation. Author

A89-30840#

EXPERIMENTS AND ANALYSIS FOR STRUCTURALLY COUPLED COMPOSITE BLADES UNDER LARGE DEFLECTIONS. I - STATIC BEHAVIOR

PIERRE MINGUET and JOHN DUGUNDJI (MIT, Cambridge, MA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1807-1816. refs
(Contract DAAL03-87-K-0024)
(AIAA PAPER 89-1365)

The static behavior of structurally coupled composite blades is being investigated in this paper analytically and experimentally. A model, based on the use of Euler angles, is developed which can account for the presence of arbitrarily large deflections without the need for any ordering scheme. A simple iterative finite-differences solution procedure is then presented. Some experiments using thin flat composite cantilevered beams are also performed, and the data obtained compared well with the results from the analysis. Author

A89-30841#

EXPERIMENTS AND ANALYSIS FOR STRUCTURALLY COUPLED COMPOSITE BLADES UNDER LARGE DEFLECTIONS. II - DYNAMIC BEHAVIOR

PIERRE MINGUET and JOHN DUGUNDJI (MIT, Cambridge, MA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1817-1827. refs
(Contract DAAL03-87-K-0024)
(AIAA PAPER 89-1366)

The dynamic behavior of structurally coupled composite blades is investigated in this paper analytically and experimentally, while the static behavior was described in Part I of this article. The model developed there is linearized around a given static position to investigate the small amplitude vibrations of composite blades. The influence coefficients method is used together with a simple iterative finite-differences solution procedure to obtain a standard eigenvalue problem. Several experiments using thin flat composite cantilevered beams are also performed and the data obtained compared well with the results from the analysis. The presence of static deflections is shown to have a significant influence on the torsion and fore-and-aft (lead-lag) modes and frequencies. Author

A89-30843*# Texas Univ., San Antonio.
PROBABILISTIC CONSTITUTIVE RELATIONSHIPS FOR MATERIAL STRENGTH DEGRADATION MODELS
L. BOYCE (Texas, University, San Antonio) and C. C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1832-1839. Research supported by the Case Institute of Computational Mechanics in Propulsion. refs
(AIAA PAPER 89-1368)

In the present probabilistic methodology for the strength of aerospace propulsion system structural components subjected to such environmentally-induced primitive variables as loading stresses, high temperature, chemical corrosion, and radiation, time is encompassed as an interacting element, allowing the projection of creep and fatigue effects. A probabilistic constitutive equation is postulated to account for the degradation of strength due to these primitive variables which may be calibrated by an appropriately curve-fitted least-squares multiple regression of experimental data. The resulting probabilistic constitutive equation is embodied in the PROMISS code for aerospace propulsion component random strength determination. O.C.

A89-30851*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INVESTIGATION OF THE 'OVERLAP' BETWEEN THE STATISTICAL-DISCRETE-GUST AND THE POWER-SPECTRAL-DENSITY ANALYSIS METHODS
BOYD PERRY, III (NASA, Langley Research Center, Hampton, VA), ANTHONY S. POTOTZKY, and JESSICA A. WOODS (Planning Research Corp., Aerospace Technologies Div., Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1899-1910. refs
(AIAA PAPER 89-1376)

This paper presents the results of a NASA investigation of a claimed 'Overlap' between two gust response analysis methods: the Statistical Discrete Gust (SDG) method and the Power Spectral Density (PSD) method. The claim is that the ratio of an SDG response to the corresponding PSD response is 10.4. Analytical results presented in this paper for several different airplanes at several different flight conditions indicate that such an 'Overlap' does appear to exist. However, the claim was not met precisely: a scatter of up to about 10 percent about the 10.4 factor can be expected. Author

A89-30857*# Purdue Univ., West Lafayette, IN.
EULER FLUTTER ANALYSIS OF AIRFOILS USING UNSTRUCTURED DYNAMIC MESHES
RUSS D. RAUSCH, HENRY T. Y. YANG (Purdue University, West Lafayette, IN), and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1963-1972. refs
(Contract NAG1-372)
(AIAA PAPER 89-1384)

Modifications to a two-dimensional unsteady Euler code for the aeroelastic analysis of airfoils are described. The modifications involve including the structural equations of motion and their simultaneous time-integration with the governing flow equations. A novel aspect of the capability is that the solutions are obtained using unstructured grids made up of triangles. Comparisons are made with parallel calculations performed using linear theory and a structured grid Euler code to assess the accuracy of the unstructured grid Euler results. Results are presented for a flat plate airfoil and the NACA 0012 airfoil to demonstrate applications of the Euler code for generalized force computations and aeroelastic analysis. In these comparisons, two different finite-volume discretizations of the Euler equations on unstructured meshes were employed. Sensitivity of the Euler results to changes in numerical parameters were also investigated. Author

A89-30876#
DELAMINATION ARRESTMENT BY DISCRETIZING THE CRITICAL PLY IN A LAMINATE
EDWARD W. Y. LEE (Bell Helicopter Textron, Fort Worth, TX) and WEN S. CHAN (Texas, University, Arlington) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 2130-2136. refs
(AIAA PAPER 89-1403)

This paper presents the development of a delamination arrestment concept. It is intended for use in the design of fail-safe and damage-tolerant structures. Free edge delamination is allowed to initiate and grow, but terminates itself at planned arrestment locations. The discrete critical ply concept, verified by analysis results and substantiated by test observations, has demonstrated the ability of arresting free edge delamination in both static and fatigue environments. The arrestment mechanism is the discontinuity in critical ply stiffness. By discretizing the critical ply, it creates local softening and introduces discontinuity in the load path, and interrupts the delamination process. Author

A89-30878*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND TESTING OF THERMAL-EXPANSION-MOLDED GRAPHITE-EPOXY HAT-STIFFENED SANDWICH PANELS
DAWN C. JEGLEY (NASA, Langley Research Center, Hampton, VA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 2146-2156. refs
(AIAA PAPER 89-1405)

Minimum weight configurations for two types of graphite-epoxy hat-stiffened compression-loaded panels fabricated by the thermal-expansion-molding (TEM) manufacturing process were evaluated analytically and experimentally for designs with load index Nx/L values ranging from 100 to 800. The two types of panels contain graphite-epoxy face sheets with a foam core and hat stiffeners which are either open or filled with foam. Constraints on the extensional and shear stiffnesses are imposed on the design so that the panels will satisfy typical constraints for aircraft wing structures. Optimal structurally efficient TEM panels are compared to commercially available aluminum aircraft structures. Predicted load-strain relationships agree well with experimental results. Significant impact damage to the unstiffened face sheet and foam core does not noticeably reduce the load carrying ability of the panels, but damage to the stiffened face sheet reduces the failure load by 20 percent compared to unimpacted panels. Author

A89-30929
THE INFLUENCE OF JET-GRID TURBULENCE ON TURBULENT BOUNDARY LAYER FLOW AND HEAT TRANSFER
J. C. HAN and C. D. YOUNG (Texas A & M University, College Station) IN: Transport phenomena in turbulent flows: Theory, experiment, and numerical simulation; Proceedings of the Second International Symposium, Tokyo, Japan, Oct. 1987. New York, Hemisphere Publishing Corp., 1988, p. 501-514. Research supported by USAF. refs

A wind tunnel with a jet-grid flat-plate test rig is described. On the basis of a specific jet-grid design, preliminary results for velocity/intensity/heat transfer profiles were obtained for two mainstream velocities for cases with and without injections. The maximum turbulence intensity could be produced from the jet-grid device by using an approximately 5 percent injection ratio. It was found that the turbulence intensity with injection was about 80-100 percent and 30-50 percent higher, respectively, than without injection at X/b = 20 and X/b = 80. K.K.

A89-30955
ANALYSIS OF LAMINATED COMPOSITE STRUCTURES
J. N. REDDY (Virginia Polytechnic Institute and State University, Blacksburg) IN: Finite element analysis for engineering design; Proceedings of the Advanced Study Institute, Madras, India, Aug. 1-10, 1988. Berlin and New York, Springer-Verlag, 1988, p. 361-425. refs

The governing equations of composite laminates can be solved either analytically or numerically. This paper addresses Navier and other analytical solutions of the classical and first-order laminate theories. Finite element models based on various formulations, including two-dimensional plate theories and a degenerate three-dimensional shell element based on the total Lagrangian formulation, are developed. C.D.

A89-30977
ENGINE GAS PATH PARTICLE ANALYSIS - A DIAGNOSTIC AID
DAVID E. LLOYD and DAVID C. EMPSON (Rolls-Royce, PLC, Bristol, England) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 15-24. Research supported by Rolls-Royce, PLC and Ministry of Defence.

The sensitivity of the GAPPA (gas path particle analysis) technique is evaluated with regard to the detection and identification of engine component distress and foreign object damage. This technique utilizes removable targets located in the engine gas stream to collect particulate debris. After removal from the engine, the surface of the targets is assessed by fully-automated energy-dispersive electron-probe microanalysis using proprietary software to characterize the particulate shape and size and determine their chemical composition. K.K.

A89-31301
COMPUTATIONAL FLUID DYNAMICS; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, SYDNEY, AUSTRALIA, AUG. 23-27, 1987
GRAHAM DE VAHL DAVIS, ED. (New South Wales, University, Kensington, Australia) and CLIVE FLETCHER, ED. (Sydney, University, Australia) Amsterdam, North-Holland, 1988, 805 p. For individual items see A89-31302 to A89-31351.

Recent advances in the numerical simulation of flow problems are discussed in reviews and reports. Topics addressed include the hydrodynamics of lattice gases, the use of Green's theorem in the solution of the Navier-Stokes equations, SUPG-type FEMs for fluid dynamics, splitting methods for the Euler and Navier-Stokes equations, the increasing use of CFD in aircraft design, and the grid-characteristic method in external gasdynamics. Consideration is given to gradient boundary conditions for turbulent flow, measurement and prediction of recirculating flows in a T-shaped cavity, acoustic refraction phenomena, a fast Euler solver for three-dimensional internal flows, an FEM model for convection-dominated transport problems, chemically non-equilibrium viscous flow on conic aerobrake bodies, vortex breakdown in confined swirling flow, aerodynamics algorithms for parallel processors, and solution techniques for the partially parabolized Navier-Stokes equations. T.K.

A89-31347* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
STUDY OF V/STOL FLOWS USING THE FORTIFIED NAVIER-STOKES SCHEME
WILLIAM R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) IN: Computational fluid dynamics; Proceedings of the International Symposium, Sydney, Australia, Aug. 23-27, 1987. Amsterdam, North-Holland, 1988, p. 725-735. refs

One of the flows inherent in V/STOL operations, the jet in ground effect with a crossflow, is studied using the Fortified Navier-Stokes (FNS) scheme. Through comparison of the simulation results and the experimental data, and through the variation of the flow parameters (in the simulation), a number of interesting characteristics of the flow have been observed. For example, it appears that the forward penetration of the ground vortex is a strong inverse function of the level of mixing in the ground vortex. An effort has also been made to isolate issues which require additional work in order to improve the numerical simulation of the jet in ground effect flow. The FNS approach simplifies the simulation of a single jet in ground effect, but will be even more effective in applications to more complex topologies. Author

A89-31529#
THE FINITE DYNAMIC ANNULAR ELEMENT FOR THE VIBRATION ANALYSIS OF VARIABLE THICKNESS DISCS
YIN-GE XU (Beijing Jiaotong Manager College, People's Republic of China) and YI-SONG ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Applied Mathematics and Mechanics (English Edition) (ISSN 0253-4827), vol. 9, Aug. 1988, p. 755-764. refs

According to the gyro-periodicity of dynamic displacements, the two-dimensional problems of circular plates with variable thickness are simplified into one-dimensional ones in this paper. Taking the expanded form of frequency power series of the dynamic displacement functions as the dynamic shape functions of the finite annular element, the mass and stiffness matrices as well as their one-order revised matrices are given succinctly. The dynamic method is used to analyze the vibration characteristics of a bladed disk assembly and is compared with conventional finite element method and experiment. It is shown to be superior to other numerical methods. Author

A89-31599
AE LOAD-CYCLE DEPENDENCE APPLIED TO MONITORING FATIGUE CRACK GROWTH UNDER COMPLEX LOADING CONDITIONS
S. J. BOWLES (Department of Defence, Aeronautical Research Laboratory, Melbourne, Australia) NDT International (ISSN 0308-9126), vol. 22, Feb. 1989, p. 7-13. refs

Acoustic emission (AE) has been used to continuously monitor fatigue-critical zones in a Mirage aircraft undergoing full-scale fatigue testing, in order to establish the feasibility of detecting AE due to crack growth during flight. The major problem was to distinguish crack growth from the many spurious AE sources. Thus, to discriminate between AE due to different sources, the activity in each zone was analyzed in terms of its load-cycle dependence. Regions on the load cycle where AE due to fatigue crack growth was most likely to occur were identified, and a correlation was found between crack growth and relatively high AE activity in this region. Active cracks deeper than 0.3-0.6 mm were detected, although the size of the AE indication was not proportional to the cracking activity and zoning calibration studies had to be taken into account. No significant cracks were missed. Author

A89-31624
VARIABLE MAGNIFICATION CONSIDERATIONS FOR AIRBORNE, MOVING MAP DISPLAYS
CHARLES P. ALLEN (Lockheed Aeronautical Systems Co., Burbank, CA) IN: Human Factors Society, Annual Meeting, 32nd, Anaheim, CA, Oct. 24-28, 1988, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1988, p. 126-129.

Color moving-map displays are increasingly being recommended for inclusion in the crewstations of modern aircraft. Research evaluates display magnification requirements for color moving-map display systems for two map scale uses, three map scales and two lighting conditions. Results show significant differences in magnification requirements for different map uses, map scales and lighting conditions. Results suggest the need for new guidelines. Author

A89-31789
INFLUENCE OF A TOUGH LAYER WITHIN AN ORTHOTROPIC PLATE ON THE MODE I STRESS INTENSITY FACTOR
NAVA SELA, LESLIE BANKS-SILLS (Tel Aviv University, Israel), and ORI ISHAI (Technion - Israel Institute of Technology, Haifa) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 32, no. 4, 1989, p. 533-543. refs

The effect of an interlayer within a composite medium on the mode-I stress intensity factor of the composite was investigated. Stress intensity factors for cracks in an isotropic material, an isotropic layer within a second isotropic material, and an orthotropic plate, that were calculated using the finite element models in conjunction with either displacement extrapolation or Griffith's energy were shown to be accurate. An orthotropic linear elastic material AS4/3502 with a tough interlayer was then analyzed, and the results were compared with a case without an inner layer. It was found that the introduction of the tough inner layer at the midplane of the cracked orthotropic plate reduces significantly the stress intensity factor; on the other hand, an increase of the inner ply thickness at each crack length leads to an increase in the stress intensity factor. It is therefore recommended that, if a tough layer is used, it should be as thin as possible. I.S.

A89-31815#
CERAMIC HEAT EXCHANGERS AND TURBINE BLADES - THEORY AND EXPERIMENTAL RESULTS [ECHANGEURS DE CHALEUR ET AUBES DE TURBINE EN CERAMIQUE - THEORIE ET RESULTATS EXPERIMENTAUX]
P. AVRAN and S. BOUDIGUES (NATO, AGARD, Specialists' Meeting on Combustion Instabilities in Liquid-Fuelled Propulsion Systems, 72nd, Bath, England, Oct. 3-7, 1988) ONERA, TP, no. 1988-157, 1988, 11 p. In French. Research supported by DRET. (ONERA, TP NO. 1988-157)

The use of ceramics both for heat exchangers, to obtain high-efficiency low-specific-fuel-consumption gas turbine cycles, and for fixed or moving turbine blades is discussed. Experimental results for two-circuit and three-circuit barrel-type ceramic heat exchangers are compared with the predictions of a simple theoretical model. Although ceramics turbine blades show decreased cooling flow and improved blade performance compared with traditional blades, they have only limited applicability. R.R.

A89-31909*#
RESONANCE PREDICTION FOR CLOSED AND OPEN WIND TUNNEL BY THE FINITE-ELEMENT METHOD
IN LEE (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 266-278) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 391-398. Previously cited in issue 18, p. 2658, Accession no. A86-38909. refs
(Contract NGL-05-020-243)

A89-31911*# Spectron Development Labs., Inc., Costa Mesa, CA.
OPTICAL BOUNDARY-LAYER TRANSITION DETECTION IN A TRANSONIC WIND TUNNEL
M. AZZAZY, D. MODARRESS (Spectron Development Laboratories, Inc., Costa Mesa, CA), and R. M. HALL (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 405-410. Previously cited in issue 18, p. 2860, Accession no. A87-42452. refs
(Contract NAS1-18207)

A89-32182
GYROSCOPIC SYSTEMS (2ND REVISED AND ENLARGED EDITION) [GIROSKOPICHESKIE SISTEMY /2ND REVISED AND ENLARGED EDITION/]
DMITRII S. PEL'POR, ED. Moscow, Izdatel'stvo Vysshaia Shkola, 1988, 424 p. In Russian. No individual items are abstracted in this volume.

The book is concerned with the theory and analysis of primary gyroscopic transducers, physical pendulums and accelerometers, gyroscopic instruments, and high-precision orientation systems. In particular, attention is given to the determination of the equilibrium position of a physical pendulum, motion of a gyroscopic pendulum in flight, angle and angular velocity transducers, optical gyroscopes, three-degrees-of-freedom gyroscopes, and course-setting gyroscopic instruments. The discussion also covers three-dimensional gyroscopic orientation systems based on dynamically tunable gyroscopes, strapped-down orientation systems, initial orientation of gyroscopic systems, and gyroscopic orientation and stabilization systems for spacecraft. V.L.

A89-32374
OPTIMUM DESIGN OF WING STRUCTURES WITH MULTIPLE FREQUENCY CONSTRAINTS
RAMANA V. GRANDHI (Wright State University, Dayton, OH) and V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 4, Feb. 1989, p. 303-313. Research supported by the Ohio State Research Challenge Program. refs
(Contract F33615-88-C-3204)

In this paper, design optimization of aircraft wing structures with multiple frequency constraints was considered. An optimality criterion algorithm along with a scaling procedure was used. Large-scale structural design problems were considered for demonstrating the reliability and efficiency of the algorithm. A simplified fighter wing, and an intermediate-complex wing were considered as design examples. Design histories and the first few frequencies at the initial and final conditions are presented. Author

N89-18441# Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Delft (Netherlands). Road-Vehicles Research Inst.
MADYMO CRASH VICTIM SIMULATIONS: A FLIGHT SAFETY APPLICATION
J. WISMANS and J. A. GRIFFIOEN *In* AGARD, Energy Absorption of Aircraft Structures as an Aspect of Crashworthiness 6 p Dec. 1988
Avail: NTIS HC A15/MF A01

MADYMO is a computer program for two- or three-dimensional simulation of human body gross motions. The program was designed particularly for crash analyses. In the past years the program was applied and validated extensively for vehicle safety research. An application is described in the field of flight safety: the simulation of a space shuttle crew escape system. Author

N89-18477# Rolls-Royce Ltd., Derby (England).
USE OF MARKOV PROBABILITY AND RELIABILITY MODEL GENERATION METHODS IN THE ANALYSIS OF RELIABILITY OF A FAULT TOLERANT, HARDWARE AND SOFTWARE BASED SYSTEM WITH FLEXIBLE REPAIR POLICIES
PAUL WHITE *In* AGARD, Software Engineering and Its Application to Avionics 23 p Nov. 1988 Previously announced as N88-28706
Avail: NTIS HC A18/MF A01

Problems in the application of traditional reliability methods to fault-tolerant systems, particularly with the fault trees approach are reviewed. The application of the Markov state-flow equation to reliability analysis is considered and it is shown how many problems disappear with this approach and how the basic equation can be manipulated to include repair policies, discrete events, and to calculate system reliability. How to set up a reliability model from system design information in such a way as to ensure the Markov states and transitions are correct and so as to ensure that the reliability analysis gives an upper bound for the system failures is outlined. Formulation of design information and automatic generation of a reliability model for any given system is explained and an example analysis is given based on a typical jet engine control system. ESA

N89-18591# Federal Armed Forces Defense Science, Munster (Germany, F.R.). Agency for NBC Protection.
EMP-INDUCED TRANSIENTS AND THEIR IMPACT ON SYSTEM PERFORMANCE
RICHARD J. STURM *In* AGARD, Effects of Electromagnetic Noise and Interference on Performance of Military Radio Communication Systems 7 p Dec. 1988
Avail: NTIS HC A18/MF A01

The interaction of electromagnetic waves with complex systems is still a puzzling phenomenon. Presented here is an attempt to show how information about the sequence of interaction steps can be extracted from the whole set of data which are recorded during an electromagnetic pulse (EMP) test of a complex system. The basic idea is to separate the interaction process in two or more steps, the external interaction, coupling through e.g., an aperture, and the internal interaction. The internal interaction results in the all important results in the all important pin currents/voltages which endanger the proper function of the system. In case of EMP the induced currents can reach peak values of more than 100 A even on short cables in compact systems (helicopters, tanks, etc.). The type of upset and damage which have been observed after illumination with EMP-like fields are reported. The basic concept of the determination of the EMP-vulnerability is discussed and explained by examples. Author

N89-18610# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
VALIDATION OF COMPUTATIONAL FLUID DYNAMICS. VOLUME 1: SYMPOSIUM PAPERS AND ROUND TABLE DISCUSSION
Dec. 1988 588 p In ENGLISH and FRENCH Symposium held in Lisbon, Portugal, 2-5 May 1988
(AGARD-CP-437-VOL-1; ISBN-92-835-0489-5; ISBN-92-835-0491-7) Avail: NTIS HC A25/MF A01

The specific intent of the examining activities, both computational and experimental, was directed toward validating or calibrating CFD codes over a broad spectrum of fluid dynamics study areas. The objectives of the Symposium were to identify the level of agreement of numerical solution algorithms and physical models with experimental and/or analytical data, to identify regions of validity for given flow solvers, and to identify flow regions where significant gaps exist and further work is warranted.

N89-18617# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
COMPARATIVE STUDY OF CALCULATION PROCEDURES FOR VISCOUS FLOWS AROUND AIRFOILS IN THE TRANSONIC REGIME
H. W. STOCK, W. HAASE, and H. ECHTLE *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 9 p Dec. 1988
Avail: NTIS HC A25/MF A01

Comparative studies for the evaluation of flows around airfoils are presented. This problem is solved in two different ways. Flows are computed by: (1) a finite volume Navier-Stokes method; and (2) an iterative calculation procedure using a finite volume method to solve the full potential equation for the inviscid flow and an inverse integral boundary layer method for the viscous part. Using the Navier-Stokes method, two different algebraic turbulence models are investigated. First, the Baldwin-Lomax model is applied followed by the Cebeci-Smith model, in combination with a recently developed approach to evaluate the turbulent length scales in Navier-Stokes method. Concerning the problem of the computation of shock wave boundary layer interaction zones, a numerical study is performed using the finite volume Navier-Stokes method. The influence of mesh refinement, in the surface normal and tangential direction, with respect to the prediction quality is studied. Two different airfoils, the RAE 2822 and the DoAL3, are investigated and compared to experimental findings. Author

N89-18618# Catania Univ. (Italy). Inst. di Macchine.
NUMERICAL SOLUTION OF COMPRESSIBLE NAVIER-STOKES FLOWS
F. BASSI, F. GRASSO, and M. SAVINI (Consiglio Nazionale delle Ricerche, Peschiera Borromeo, Italy) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 14 p Dec. 1988
Avail: NTIS HC A25/MF A01

A mesh embedding technique for increasing the accuracy of Navier-Stokes computations of compressible flows is presented and fully described. The method proposed is quite robust and the results obtained by appling it to transonic airfoil computations are in fairly good agreement with the experiments and with computations made by other authors using much finer meshes. Thus this technique allows the computation of such flows for practical use even on small computers. Author

N89-18619# National Aerospace Lab., Amsterdam (Netherlands).
THE INTERNATIONAL VORTEX FLOW EXPERIMENT
A. ELSENAAR, L. HJELMBERG, K. BUETEFISCH, and W. J. BANNINK (Technische Hogeschool, Delft, Netherlands) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 23 p Dec. 1988
Avail: NTIS HC A25/MF A01

Experimental results of the International Vortex Flow Experiment are presented. In this joint program, the vortex flow development on a 65 deg delta wing was studied for Mach numbers between 0.4 and 4. The experimental results include pressure and force measurements, surface flow visualizations and flow field surveys. The influence of leading edge shape (sharp or rounded), a decrease in leading edge sweep (to 55 deg), the addition of a canard wing and yaw effects were measured and analyzed in some detail as far as vortex development, shock wave formation and vortex break-down are concerned. Particular attention was given to experimental details that affect the comparison with theory. Some specific test cases for computer code validation are recommended. Author

N89-18620# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
STATUS OF CFD VALIDATION ON THE VORTEX FLOW EXPERIMENT
B. WAGNER, S. M. HITZEL, M. A. SCHMATZ, W. SCHWARZ, A. HILGENSTOCK, and S. SCHERR (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 10 p Dec. 1988
Avail: NTIS HC A25/MF A01

The vortex flow phenomena developing at highly swept wings by leading edge separation are of great interest for fighter and missile aerodynamics. While panel methods are already known for more than a decade to satisfactorily model the roll-up of the corresponding vortex sheets at subsonic speed, Euler methods became available in the early 80's for predicting these effects also in the transonic and supersonic speed ranges. Subsequent trials to validate such transonic vortex flow computations revealed the experimental data basis to be very poor for high speeds and, in consequence, the International Vortex Flow Experiment on Euler Code Validation was set up. More recently, also three dimensional Navier-Stokes codes could be applied in order to clarify the role of viscous effects and to investigate in detail the neglect of those in the Euler solutions. A survey is presented on the Euler code validation based on the Symposium on the IVFE in 1986 and additional insight is given into some related Euler and Navier-Stokes work done in West Germany more recently. Author

N89-18621# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
FLOW FIELD SURVEYS OF LEADING EDGE VORTEX FLOWS
T. T. NG, R. C. NELSON, and F. M. PAYNE (Boeing Commercial Airplane Co., Seattle, WA.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table

Discussion 13 p Dec. 1988
Avail: NTIS HC A25/MF A01

The phenomenon of vortex breakdown over slender delta wings is examined experimentally. Measurements of leading edge vortex structures were obtained using both flow visualization and detailed wake surveys using either a seven hole pressure probe or a laser Doppler anemometer. The structure of the leading edge vortex on a family of delta wings is presented. The delta wing models were sharp-edge flat plates having leading edge sweep angles of 70, 75, 80 and 85 degs. These models were tested at angles of attack of 10, 20, 30 and 40 degs in a Reynolds number range of 8.5 x 10,000 to 6.4 x 100,000. Data is presented on vortex trajectories, wake surveys, and swirl angles before and after vortex breakdown. In addition, the effect of Reynolds number on the vortex surveys is discussed. The data presented represents a portion of a large experimental data base that should be of value to the development and validation of computational models of leading edge vortices. Author

N89-18625# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).

VERIFICATION OF AN IMPLICIT RELAXATION METHOD FOR STEADY AND UNSTEADY VISCOUS AND INVISCID FLOW PROBLEMS

M. A. SCHMATZ, A. BRENNEIS, and A. EBERLE *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 33 p Dec. 1988
Avail: NTIS HC A25/MF A01

A 3-D Navier-Stokes code (NSFLEX) and an unsteady Euler code (INFLEX3) is described. The fundamental feature of both methods is a Godunov type averaging procedure based on an eigenvalue analysis of the inviscid equations for the calculation of the inviscid fluxes. Up to 3rd order accuracy in space is employed for the flux calculation. The unfactored implicit equations are solved in time dependent form by a Newton method. Relaxation is performed with a point Gauss-Seidel technique. Both codes are highly vectorized. Because the codes are finite volume schemes, they are flexible in handling complex geometries. The NSFLEX is applied to steady viscous 2-D airfoil and 3-D delta wing flows at transonic Mach numbers including vortices. The method compares very well with the experiment. The INFLEX method is applied to the unsteady Euler equations in order to predict time accurate, unsteady, subsonic and transonic flows about 3-D configurations oscillating in the flow. Numerical results are given for a rectangular supercritical wing and the so-called LANN-wing. Comparisons show good agreement with experiments for a wide range of Mach numbers. Viscous effects, especially at the rear of the wing, explain some deviations. Author

N89-18635*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

CFD VALIDATION EXPERIMENTS FOR INTERNAL FLOWS

LOUIS A. POVINELLI *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 13 p Dec. 1988 Previously announced as N88-16679
Avail: NTIS HC A25/MF A01 CSCL 20D

Computational Fluid Dynamics (CFD) validation experiments at NASA Lewis are described. The material presented summarized the research in 3 areas: Inlets, ducts and nozzles; Turbomachinery; and Chemically reacting flows. The specific validation activities are concerned with shock boundary layer interactions, vortex generator effects, large low speed centrifugal compressor measurements, transonic fan shock structure, rotor/stator kinetic energy distributions, stator wake shedding characteristics, boundary layer transition, multiphase flow and reacting shear layers. These experiments are intended to provide CFD validation data for the internal flow fields within aerospace propulsion system components. Author

N89-18638# Pennsylvania State Univ., University Park. Aerospace Engineering Dept.

COMPUTATIONAL TECHNIQUES AND VALIDATION OF 3D VISCOUS/TURBULENT CODES FOR INTERNAL FLOWS

B. LAKSHMINARAYANA, K. R. KIRTLEY, and M. WARFIELD *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 17 p Dec. 1988 Sponsored in part by Naval Ship Research and Development Center, Bethesda, MD
Avail: NTIS HC A25/MF A01

The computational techniques and codes developed for the prediction of 3-D turbulent flows in internal configurations and rotor passages are described. Detailed calibration and validation of the flow fields in 90 deg curved ducts, cascades, end wall flows and turbomachinery rotors are presented. Interpretation and comments on accuracy, level of agreement with various turbulence models and limitations of the codes are described. The single pass space marching code is found to be efficient for curved duct and 2-D cascade flows. Multipass space marching, time marching and zonal methods are found to be accurate for complex situations. The efficiency and accuracy of a zonal technique, with saving in computational time, is demonstrated. Author

N89-18639# Institut de Mecanique des Fluides de Marseille (France).

WIND TUNNEL VALIDATION OF AERODYNAMIC FIELD CALCULATION CODES FOR ROTORS AND PROPELLERS IN VARIOUS FLIGHT CONDITIONS [VALIDATION A L'AIDE D'ESSAIS EN SOUFFLERIE DE CODES DE CALCUL DU CHAMP AERODYNAMIQUE DE ROTORS ET D'HELICES DANS DES CONDITIONS DE VOL VARIEES]

C. MARESCA, D. FAVIER, M. NSI MBA, and C. BARBI *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 16 p Dec. 1988 In FRENCH
Avail: NTIS HC A25/MF A01

The aerodynamic characteristics of helicopter rotors and propellers operating in various flight modes were studied using both numerical codes and wind tunnel tests. The use of the wind tunnel results to validate and improve three computational codes is discussed. The codes specifically cover helicopter rotors in stationary (hovering) flight, propellers in translational flight, and helicopter rotors in forward flight. Author

N89-18640# Norges Tekniske Hoegskole, Trondheim. Div. of Hydro- and Gas Dynamics.

VALIDATION OF A 3D EULER/NAVIER-STOKES FINITE VOLUME SOLVER FOR A RADIAL COMPRESSOR

LARS-ERIK ERIKSSON and JAN TORE BILLDAL *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 19 p Dec. 1988
Avail: NTIS HC A25/MF A01

The application of a time marching Euler Navier-Stokes solution procedure to 3-D compressible turbomachinery flow is described. The method is based on the cell-centered finite volume technique and explicit Runge-Kutta time stepping. A centered and compact difference scheme is used to obtain the velocity and temperature gradients needed in the viscous flux terms and a standard algebraic turbulence model is included in the method. Computational results for the well known Eckardt impeller show that the viscous model comes significantly closer to the experimental data than the Euler model. The results of a thin layer version of the viscous solver are in very close agreement with those of the full Navier-Stokes solver. Author

N89-18643# Air Force Systems Command, Wright-Patterson AFB, OH. Aeronautical Systems Div.

EFFORTS TOWARD THE VALIDATION OF A COMPUTATIONAL FLUID DYNAMICS CODE FOR ANALYSIS OF INTERNAL AERODYNAMICS

R. G. SEMMES, D. G. ARBITER, and R. D. DYER *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium

Papers and Round Table Discussion 13 p Dec. 1988
Avail: NTIS HC A25/MF A01

A two-dimensional/axisymmetric, Reynolds averaged Navier-Stokes code (PARC2D) was selected to aid in the analysis of internal aerodynamics problems. Before implementing the code in actual systems applications, the code's results were compared with experimental data to determine the extent of its usefulness. The configurations chosen for code validation were: (1) a two-dimensional hypersonic inlet, (2) an axisymmetric convergent-divergent nozzle, and (3) an axisymmetric subsonic diffuser. The ability of the method to readily perform engineering predictions on internal aerodynamics problems is discussed. Sample grids for each configuration as well as comparisons of computational and experimental results are presented. The PARC2D code was able to predict the hypersonic inlet flow field trends and shock structure, but had difficulty in predicting forebody losses. PARC2D provided good agreement with experimental data for both the nozzle as well as the subsonic diffuser. Author

N89-18647*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A COMPARATIVE STUDY AND VALIDATION OF UPWIND AND CENTRAL-DIFFERENCE NAVIER-STOKES CODES FOR HIGH-SPEED FLOWS

DAVID H. RUDY, AJAY KUMAR, JAMES L. THOMAS, PETER A. GNOFFO, and SUKUMAR R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA.) *In* AGARD, Validation of Computational Fluid Dynamics. Volume 1: Symposium Papers and Round Table Discussion 15 p Dec. 1988
Avail: NTIS HC A25/MF A01 CSCL 20D

A comparative study was made using 4 different computer codes for solving the compressible Navier-Stokes equations. Three different test problems were used, each of which has features typical of high speed internal flow problems of practical importance in the design and analysis of propulsion systems for advanced hypersonic vehicles. These problems are the supersonic flow between two walls, one of which contains a 10 deg compression ramp, the flow through a hypersonic inlet, and the flow in a 3-D corner formed by the intersection of two symmetric wedges. Three of the computer codes use similar recently developed implicit upwind differencing technology, while the fourth uses a well established explicit method. The computed results were compared with experimental data where available. Author

N89-18648# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.

VALIDATION OF COMPUTATIONAL FLUID DYNAMICS. VOLUME 2: POSTER PAPERS

Dec. 1988 239 p Symposium held in Lisbon, Portugal, 2-5 May 1988
(AGARD-CP-437-VOL-2; ISBN-92-835-0490-9; ISBN-92-835-0491-7) Avail: NTIS HC A11/MF A01

AGARD's Fluid Dynamics Panel has sponsored a Symposium with the specific intent of examining activities, both computational and experimental, directed toward validating or calibrating computational fluid dynamics (CFD) codes over a broad spectrum of fluid-dynamics study areas. The objectives of the Symposium were to identify the level of agreement of numerical solution algorithms and physical models with experimental and/or analytical data, to identify regions of validity for given flow solvers, and to identify flow regions where significant gaps exist and further work is warranted.

N89-18662# Technische Univ., Brunswick (Germany, F.R.). Inst. fuer Stroemungsmechanik.

DOCUMENTATION OF SEPARATED FLOWS FOR COMPUTATIONAL FLUID DYNAMICS VALIDATION

DIETRICH HUMMEL *In* AGARD, Validation of Computational Fluid Dynamics. Volume 2: Poster Papers 24 p Dec. 1988
(Contract DFG-SCHL-5/82; HU254/2; HU254/8; BMVG-T/RF41/90010/91454; BMVG-T/RF41/D0011/01411)
Avail: NTIS HC A11/MF A01

In recent years a large number of separated flows have been studied at Institute fur Stromungsmechanik of TU Braunschweig and a lot of experimental data are available. Some flows are well understood in many details and properly documented, so that they can be used as test cases for computational fluid dynamics validation. The topics of separated flows to be treated here are low speed flows around delta wings, double-delta wings and canard configurations as well as hypersonic flows in axial corners of intersecting wedges. The experimental results are summarized. The main results are presented and a detailed documentation is provided on where and in which form these results are available. Author

N89-18664*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

HIGH-RESOLUTION LIQUID-CRYSTAL HEAT-TRANSFER MEASUREMENTS ON THE END WALL OF A TURBINE PASSAGE WITH VARIATIONS IN REYNOLDS NUMBER

STEVEN A. HIPPENSTEELE and LOUIS M. RUSSELL 1988 15 p Presented at the 25th National Heat Transfer Conference, Houston, TX, 24-27 Jul. 1988; sponsored by ASME
(NASA-TM-100827; E-4004; NAS 1.15:100827) Avail: NTIS HC A03/MF A01 CSCL 20D

Local heat-transfer coefficients were experimentally mapped on the end-wall surface of a three-times turbine vane passage in a static, single-row cascade operated with room-temperature inlet air over a range of Reynolds numbers. The test surface was a composite of commercially available materials: a Mylar sheet with a layer of cholesteric liquid crystals, which change color with temperature, and a heater made of a polyester sheet coated with vapor-deposited gold, which produces uniform heat flux. After the initial selection and calibration of the composite sheet, accurate, quantitative, and continuous heat-transfer coefficients were mapped over the end-wall surface. The local heat-transfer coefficients (expressed as nondimensional Stanton number) are presented for inlet Reynolds numbers (based on vane axial chord) from 0.83 x 10(5) to 3.97 x 10(5). Author

N89-18665*# Boeing Commercial Airplane Co., Seattle, WA. New Product Development Organization.

FLIGHT SURVEY OF THE 757 WING NOISE FIELD AND ITS EFFECTS ON LAMINAR BOUNDARY LAYER TRANSITION. VOLUME 1: PROGRAM DESCRIPTION AND DATA ANALYSIS Report, Nov. 1984 - Jul. 1985

Mar. 1987 207 p
(Contract NAS1-15325)
(NASA-CR-178216; NAS 1.26:178216; D6-53196-1-VOL-1) Avail: NTIS HC A10/MF A01 CSCL 20D

It was previously observed that an incident acoustic field on a wing with laminar flow can cause transition to turbulent flow if the fluctuating acoustic velocities are of sufficient amplitude and in the critical frequency range for an unstable laminar boundary layer. A section of a wing was modified with a natural laminar flow (NLF) glove to allow direct measurement of the effect of varying engine noise on the extent of laminar flow. The flight test program was completed in June, 1985. At each flight condition, the engine power was varied from about 2600 r/min (idle) to about 4500 r/min (maximum continuous power). The spectral data provides considerable insight into the influences of the various sound sources that contribute to the overall noise levels. Additional analysis will be required to assess the impact of these sources on boundary layer transition. These results demonstrate that substantial laminar flow on the wing of a transport configuration with wing-mounted engines can be obtained. B.G.

N89-18675# Rolls-Royce Ltd., Derby (England). Electronics and Measurement Techniques Dept.

OPTICAL SENSORS AND SIGNAL PROCESSING SCHEMES FOR USE ON GAS TURBINE ENGINES

I. DAVINSON 2 May 1988 10 p Presented at the 34th International Instrumentation Symposium, Albuquerque, NM, 2-6 May 1988 Sponsored by the Ministry of Defence Procurement Executive, London, England
(PNR90480; ETN-89-93679) Avail: NTIS HC A02/MF A01

Probes developed for use in an active tip clearance control system are described. Closed loop active control of high pressure turbine tip clearance is achieved over a simulated flight cycle using the outputs from optical triangulation probes. These probes are not to be used in actual operation. They serve as an accurate reference against which to judge other sensors which are being investigated. ESA

N89-18689# Rolls-Royce Ltd., Derby (England).
THE MEASUREMENT OF RESIDUAL STRESSES IN CASE HARDENED BEARING COMPONENTS BY X-RAY DIFFRACTION
P. J. SPINK 28 Mar. 1988 8 p Presented at the British Crystallographic Association Conference, Coventry, England, 28 Mar. 1988
(PNR90482; ETN-89-93680) Avail: NTIS HC A02/MF A01

Measurements are made through the case of a gas turbine carburized bearing ring to a depth of 2 mm, using X-ray diffraction techniques coupled with material removal by chemical machining processes. The stress profile of two bearing samples is presented. The residual stress levels measured, associated with the carburizing process are greater than -200 MPa (compressive) to a depth of 1 mm. ESA

N89-18690# Rolls-Royce Ltd., Coventry (England).
FUEL FLEXIBILITY IN INDUSTRIAL GAS TURBINES
J. WILLIS 9 May 1988 35 p Presented at the Workshop on Alternative Fuels for Transportation: Canadian Research Needs, Ottawa, Ontario, 9-10 May 1988
(PNR90490; ETN-89-93686) Avail: NTIS HC A03/MF A01

Development work to increase the use of crude fuel and low calorific value gases is outlined. A large variety of fuels were tested. A list of the more unusual fuels that were burnt is presented. The ability of aero derivative units to operate satisfactorily on low calorific value gases is demonstrated. The suitability of a specific gas can be determined from the information presented. ESA

N89-18692# Stuttgart Univ. (Germany, F.R.). Inst. fuer Thermische Stroemungsmaschinen und Maschinenlab.
CALCULATION OF THE EIGENVIBRATION BEHAVIOR OF COUPLED BLADINGS OF AXIAL TURBOMACHINES Ph.D. Thesis [ZUR BERECHNUNG DES EIGENSCHWINGUNGSVERHALTENS GEKOPPELTER BESCHAUFELUNGEN AXIALER TURBOMASCHINEN]
JUERGEN F. MAYER 1987 170 p In GERMAN
(ETN-89-93799) Avail: NTIS HC A08/MF A01

The eigenvibration behavior of coupled bladings of axial turbomachines was calculated using the finite element method. Existing finite element program systems were combined with the method of propogation waves that uses the periodicity of the structures and substantially reduces the calculation time. The initial static stress in the blades due to the centrifugal force affects the eigenfrequencies and can be calculated, taking geometrically nonlinear effects into account. To secure the coupling conditions the eigenfrequencies calculated for several configurations and models were checked with experimentally obtained resonance frequencies. The eigenvibration calculation for a real end stage blading shows that the calculation method is also suited for the eigenvibration analysis of more complex structures. ESA

N89-18696*# Aerostructures, Inc., Arlington, VA.
MODAL FORCED VIBRATION ANALYSIS OF AERODYNAMICALLY EXCITED TURBOSYSTEMS Final Report
V. ELCHURI Jul. 1985 133 p
(Contract NAS3-24387)
(NASA-CR-174966; NAS 1.26:174966) Avail: NTIS HC A07/MF A01 CSCL 20K

Theoretical aspects of a new capability to determine the vibratory response of turbosystems subjected to aerodynamic excitation are presented. Turbosystems such as advanced turbopropellers with highly swept blades, and axial-flow compressors and turbines can be analyzed using this capability. The capability has been developed and implemented in the April 1984 release of the general purpose finite element program NASTRAN. The dynamic response problem is addressed in terms of the normal modal coordinates of these tuned rotating cyclic structures. Both rigid and flexible hubs/disks are considered. Coriolis and centripetal accelerations, as well as differential stiffness effects are included. Generally non-uniform steady inflow fields and uniform flow fields arbitrarily inclined at small angles with respect to the axis of rotation of the turbosystem are considered sources of aerodynamic excitation. The spatial non-uniformities are considered to be small deviations from a principally uniform inflow. Subsonic and supersonic relative inflows are addressed, with provision for linearly interpolating transonic airloads. Author

N89-19237*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ROLE OF COMPUTATIONAL FLUID DYNAMICS IN UNSTEADY AERODYNAMICS FOR AEROELASTICITY
GURU P. GURUSWAMY (Sterling Federal Systems, Moffett Field, CA.) and PETER M. GOORJIAN *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 1 p 47-61 Feb. 1989
Avail: NTIS HC A12/MF A01 CSCL 20D

In the last two decades there have been extensive developments in computational unsteady transonic aerodynamics. Such developments are essential since the transonic regime plays an important role in the design of modern aircraft. Therefore, there has been a large effort to develop computational tools with which to accurately perform flutter analysis at transonic speeds. In the area of Computational Fluid Dynamics (CFD), unsteady transonic aerodynamics are characterized by the feature of modeling the motion of shock waves over aerodynamic bodies, such as wings. This modeling requires the solution of nonlinear partial differential equations. Most advanced codes such as XTRAN3S use the transonic small perturbation equation. Currently, XTRAN3S is being used for generic research in unsteady aerodynamics and aeroelasticity of almost full aircraft configurations. Use of Euler/Navier Stokes equations for simple typical sections has just begun. A brief history of the development of CFD for aeroelastic applications is summarized. The development of unsteady transonic aerodynamics and aeroelasticity are also summarized. Author

N89-19473# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
TDWR (TERMINAL DOPPLER WEATHER RADAR) SCAN STRATEGY REQUIREMENTS
S. D. CAMPBELL and M. W. MERRITT 3 Nov. 1988 21 p
(Contract F19628-85-C-0002)
(AD-A201785; DOT/FAA/PM-87-22) Avail: NTIS HC A03/MF A01 CSCL 17I

The requirements for the scan strategy to be employed in the Terminal Doppler Weather Radar (TDWR) are described. The report is divided into three main sections: rationale, example scan strategy and requirements. The rationale for the TDWR scan strategy is presented in terms of: (1) detection of meteorological phenomena, and (2) minimization of range and velocity folding effects. Next, an example is provided based on an experimental scan strategy used in Denver during the summer of 1987. Finally, the requirements for the TDWR scan strategy are presented based on the preceeding discussion. Also, an appendix is included describing the proposed criteria for switching between scan modes. GRA

N89-19500 Virginia Polytechnic Inst. and State Univ., Blacksburg.
CURVATURE EFFECTS ON THE STABILITY OF THREE-DIMENSIONAL LAMINAR BOUNDARY LAYERS Ph.D. Thesis
FAYETTE SMITH COLLIER, JR. 1988 114 p
Avail: Univ. Microfilms Order No. DA8817402

The linear stability equations which govern the growth of small periodic disturbances for compressible, three-dimensional laminar boundary layer flow are derived in an orthogonal curvilinear coordinate system. The parallel flow assumption is utilized in the

derivation. The system of equations is solved using a finite difference scheme similar to that in a current state-of-the-art stability analysis code, COSAL. The LR method and the inverse Rayleigh iteration procedure are used to calculate the eigenvalues. The stability of the three-dimensional compressible laminar boundary layer including the effects of streamline and surface curvature for flows past swept wings were crossflow type disturbances dominate is calculated. A parametric study is performed varying Reynolds number and sweep angle on an airfoil with a concave cutout in the leading edge region of the lower surface. The magnitude of these effects for swept wing flows is determined. Non-stationary as well as stationary disturbances are calculated, and the most amplified frequencies are identified. N-factor correlations at the measured location of transition are made utilizing flight test data.
Dissert. Abstr.

N89-19504*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
A COMPUTATIONALLY EFFICIENT MODELLING OF LAMINAR SEPARATION BUBBLES Semiannual Status Report, Jun. 1988 - Jan. 1989
PAOLO DINI and MARK D. MAUGHMER Feb. 1989 48 p
(Contract NAG1-778)
(NASA-CR-184789; NAS 1.26:184789) Avail: NTIS HC A03/MF A01 CSCL 20D

The goal is to accurately predict the characteristics of the laminar separation bubble and its effects on airfoil performance. Toward this end, a computational model of the separation bubble was developed and incorporated into the Eppler and Somers airfoil design and analysis program. Thus far, the focus of the research was limited to the development of a model which can accurately predict situations in which the interaction between the bubble and the inviscid velocity distribution is weak, the so-called short bubble. A summary of the research performed in the past nine months is presented. The bubble model in its present form is then described. Lastly, the performance of this model in predicting bubble characteristics is shown for a few cases. Author

N89-19505*# Boeing Commercial Airplane Co., Seattle, WA. New Product Development Organization.
FLIGHT SURVEY OF THE 757 WING NOISE FIELD AND ITS EFFECTS ON LAMINAR BOUNDARY LAYER TRANSITION. VOLUME 2: DATA COMPILATION Report, Nov. 1984 - Jul. 1985
Mar. 1987 382 p
(Contract NAS1-15325)
(NASA-CR-178217; NAS 1.26:178217; D6-53196-2-VOL-2) Avail: NTIS HC A17/MF A01 CSCL 20D

A flight test program was performed using the Boeing 757 flight research airplane to investigate the effect of noise from wing mounted engines on laminar boundary layer transition. An NLF glove was installed on the right wing panel just outboard of the engine. The extent of laminar flow on the glove was measured as a function of engine power setting for a range of flight conditions. A combination of surface and probe microphones was distributed over the upper and lower wing surfaces to measure sound spectra. The flight test program was completed in June 1985 and the results of preliminary analysis indicate that a maximum of about 29 percent of chord laminar flow was obtained on the upper surface and about 28 percent on the lower surface (at a high sideslip condition). The engine speed was varied from about 2600 (idle) to about 4500 (maximum continuous power) r/min. This produced changes in sound pressure level up to 20 dB on the lower surface. On the upper surface, the noise levels were independent of engine power but sensitive to airplane Mach number. No effect of engine power setting on upper surface transition location was observed, and only a small forward movement of the transition location on the lower surface was observed at the high power settings. Volume 1 of this report contains the program description and data analysis. Volume 2 is a compilation of all of the flight test data. Author

N89-19509# McDonnell-Douglas Corp., Long Beach, CA.
THE BIRTH OF OPEN SEPARATION ON A PROLATE SPHEROID Final Report, Mar. 1986 - Sep. 1988
TUNCER CEBECI and WENHAN SU Sep. 1988 30 p
(Contract F49620-84-C-0007)
(AD-A201350; MDC-K0171; AFOSR-88-1178TR) Avail: NTIS HC A03/MF A01 CSCL 20D

Results are presented to describe the laminar flow patterns around a prolate spheroid at angles of attack of 1, 2, 3, and 30 degrees and complement those obtained previously at 6 degrees. They were obtained by solving three-dimensional boundary layer equations with a combination of standard and characteristic box methods and with a stability criterion to ensure numerical accuracy. Emphasis is placed on the nature of separation which, in agreement with experiment but contrary to some theoretical claims, is shown to be open for all angles of attack and to be coincident with a particular skin friction line. GRA

N89-19510# Drexel Univ., Philadelphia, PA. Dept. of Mechanical Engineering and Mechanics.
CHARACTERISTIC TIME MODEL VALIDATION Final Technical Report, Oct. 1984 - Jun. 1988
K. V. TALLIO, J. C. PRIOR, JR., and A. M. MELLOR Sep. 1988 182 p
(Contract DAAG29-84-K-0165)
(AD-A201374; ARO-21743.4-EG) Avail: NTIS HC A09/MF A01 CSCL 20D

An experimental program for validation of the semi-empirical Characteristic Time Model (CTM) is described. A two-dimensional turbulent shear layer is generated in the experimental test section using a two-stream, vertically downflowing wind tunnel with a flat pre-filming airblast atomizer fitted along its centerline. This facility simulates the shear layer around the recirculation zone found in the primary zone of a gas turbine combustor. Experimental results are used to investigate CTM parameters for turbulent mixing and droplet lifetime and to examine current finite difference modeling techniques. Global mixing times evaluated at the origin of the shear layer and defined in terms of geometric macroscale and a reference velocity are compared with the locally measured values of turbulent mixing time. The results demonstrate that these global times, as defined for the CTM, do in fact accurately represent the events occurring on a local scale, as hypothesized. Modifications to the mixing time parameter to improve existing correlations are proposed. Due to restrictions imposed by the facility and instrumentation, validation of the droplet lifetime parameter was not possible. Measurements were restricted to mean spray diameters. These data and others demonstrate that current correlations for Sauter mean diameter do not adequately account for changes in atomizer geometry or liquid properties. GRA

N89-19525# Rolls-Royce Ltd., Derby (England).
COMPUTATIONAL FLUID DYNAMICS FOR COMBUSTION APPLICATIONS
C. H. PRIDDIN 5 Sep. 1988 16 p Presented at Flucome '88, Sheffield, England, 5-8 Sep. 1988
(PNR90534; ETN-89-93703) Avail: NTIS HC A03/MF A01

Computational fluid dynamics as applied to combustion problems is summarized. Mesh generation, algorithm classification, combustion models, turbulence models, and pollutant emissions are surveyed. Aspects relevant to the calculation of gas turbine combustors, and the impact of such methods on the combustion development process are outlined. It is shown that although there are still large areas of research to be undertaken, models are already proving valuable in addressing real industrial combustion topics. Further developments to substantially advance the usefulness and reduce the cost of such calculations are predicted. ESA

N89-19556*# Boeing Commercial Airplane Co., Seattle, WA.
AN EXPERIMENTAL EVALUATION OF S-DUCT INLET-DIFFUSER CONFIGURATIONS FOR TURBOPROP OFFSET GEARBOX APPLICATIONS Final Report
PAUL L. MCDILL Jul. 1986 126 p Sponsored by NASA,

Lewis Research Center, Cleveland, Ohio
(NASA-CR-179454; NAS 1.26:179454; D6-53344) Avail: NTIS HC A07/MF A01 CSCL 13I

A test program, utilizing a large scale model, was run in the NASA Lewis Research Center 10- by 10-ft wind tunnel to examine the influence on performance of design parameters of turboprop S-duct inlet/diffuser systems. The parametric test program investigated inlet lip thickness, inlet/diffuser cross-sectional geometry, throat design Mach number, and shaft fairing shape. The test program was run at angles of attack to 15 deg and tunnel Mach numbers to 0.35. Results of the program indicate that current design techniques can be used to design inlet/diffuser systems with acceptable total pressure recovery, but several of the design parameters, notably lip thickness (contraction ratio) and shaft fairing cross section, must be optimized to prevent excessive distortion at the compressor face. Author

N89-19571# Rolls-Royce Ltd., Derby (England). Transmission Research and Development Dept.
GEAR TECHNOLOGY ACQUISITION FOR ADVANCED AERO ENGINES
G. A. HALLS 10 Jun. 1987 19 p Presented at the International Mechanical Engineering Meeting, 10 Jun. 1987
(PNR90510; ETN-89-93694) Avail: NTIS HC A03/MF A01

Computer controlled facilities installed to test mechanical transmission systems are described, including program logic controllers which control the sequencing and operation of the main electrically driven machinery, the integrated instrumentation system, and the environment testing facilities. The main test programs are described, including large gearbox research, and gear dynamics and lubrication rig. ESA

N89-19583*# Aerostructures, Inc., Arlington, VA.
NASTRAN SUPPLEMENTAL DOCUMENTATION FOR MODAL FORCED VIBRATION ANALYSIS OF AERODYNAMICALLY EXCITED TURBOSYSTEMS Final Report
V. ELCHURI and P. R. PAMIDI (RPK Corp., Columbia, MD.) Jul. 1985 133 p
(Contract NAS3-24387)
(NASA-CR-174967; NAS 1.26:174967) Avail: NTIS HC A07/MF A01 CSCL 20K

This report is a supplemental NASTRAN document for a new capability to determine the vibratory response of turbosystems subjected to aerodynamic excitation. Supplements of NASTRAN Theoretical, User's, Programmer's, and Demonstration Manuals are included. Turbosystems such as advanced turbopropellers with highly swept blades, and axial-flow compressors and turbines can be analyzed using this capability, which has been developed and implemented in the April 1984 release of the general purpose finite element program NASTRAN. The dynamic response problem is addressed in terms of the normal modal coordinates of these tuned rotating cyclic structures. Both rigid and flexible hubs/disks are considered. Coriolis and centripetal accelerations, as well as differential stiffness effects are included. Generally nonuniform steady inflow fields and uniform flow fields arbitrarily inclined at small angles with respect to the axis of rotation of the turbosystem are considered as the sources of aerodynamic excitation. The spatial nonuniformities are considered to be small deviations from a principally uniform inflow. Subsonic relative inflows are addressed, with provision for linearly interpolating transonic airloads. Author

N89-19597# General Dynamics Corp., Fort Worth, TX. Fort Worth Div.
ADVANCED DURABILITY ANALYSIS. VOLUME 4: EXECUTIVE SUMMARY Final Technical Report, Oct. 1984 - Sep. 1987
S. D. MANNING and J. N. YANG 31 Jul. 1988 63 p Prepared in cooperation with United Analysis, Inc., Vienna, VA
(Contract F33615-84-C-3208)
(AD-A202304; AFWAL-TR-86-3017-VOL-4) Avail: NTIS HC A04/MF A01 CSCL 11F

This report is volume 4 of a 5-volume final report on the work conducted under AF contract F33615-84-C-3208. The objectives of this program were to: (1) recommend improvements to the current Air Force durability design requirements (i.e., MIL-A-8866B and MIL-A-87221), (2) develop a probabilistic durability analysis method capable of predicting the durability of advanced metallic aircraft structure for functional impairment such as excessive cracking, fuel leakage and ligament breakage, and (3) update the current Air Force Durability Design Handbook (AFWAL-TR-83-3027). Fatigue cracking is the form of degradation considered. This three-phase program consisted of eight tasks. Advanced durability analysis methods were developed and refined under Phase 1. Fatigue test results and fractographic data were acquired and evaluated under Phase 2. Phase 3 was concerned with durability, fatigue, equivalent initial flaw size (EIFS), initial fatigue quality (IFQ), time-to-crack initiation (TICI), deterministic and stochastic crack growth. GRA

N89-19602# Technische Univ., Delft (Netherlands).
FATIGUE CRACK GROWTH IN ARALL: A HYBRID ALUMINUM ARAMID COMPOSITE MATERIAL. CRACK GROWTH MECHANISMS AND QUANTITATIVE PREDICTIONS OF THE CRACK GROWTH RATES Ph.D. Thesis
ROELOF MARISSEN 1988 351 p
(ETN-89-93899) Avail: NTIS HC A15/MF A01

The fatigue crack growth behavior of small and large cracks in ARALL was investigated under constant amplitude and flight simulation loading. Static properties, delamination in the fiber-adhesive layer under cyclic loads, and shear deformations in the fiber-adhesive layer under static and cyclic loads were tested to provide material data for a model for the prediction of fatigue crack growth in ARALL. The thickness of the aluminum sheet layers and the fiber-adhesive layers; different types of adhesives and fibers; and residual stress systems introduced by prestraining or prestressing were examined. The excellent crack growth resistance of ARALL under constant-amplitude and variable-amplitude loading is confirmed. The resistance is considerably enhanced by a favorable residual stress system, i.e., compressive stress in the aluminum alloy layers and tensile stress in the aramid fibers. Thinner individual layers also lead to better properties. The favorable residual stress system is very effective under constant-amplitude loading at low R-ratios. At high R-ratios the effect is less pronounced. Truncation of the TWIST load spectrum has a significant effect on fatigue crack growth in ARALL. A high truncation level considerably reduces crack growth rate. Initiation of small cracks in side notched specimens occurs relatively early in the fatigue life. The delamination growth rate observed in delamination tests, and crack opening displacements due to adhesive shear deformation, are directly dependent on the load transfer from the fibers to the aluminum alloy layers. ESA

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A89-29164*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SEVERE WINDS IN THE DALLAS/FT. WORTH MICROBURST MEASURED FROM TWO AIRCRAFT
R. C. WINGROVE and R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 26, March 1989, p. 221-224. Previously cited in issue 22, p. 3628, Accession no. A87-50459. refs

A89-29214#
SIMPLE MODEL OF LIGHTNING RETURN-STROKE SIMULATIONS
G. LABAUNE, I. TAUDIERE, A. BONDIOU, F. ISSAC (ONERA, Chatillon-sous-Bagneux, France), F. MORILLON (Electricite de

France, Centre des Renardieres, Moret-sur-Loing, France) et al. (International Conference on Lightning Protection, 19th, Graz, Austria, Apr. 25-29, 1988) ONERA, TP, no. 1988-27, 1988, 6 p. Research supported by DRET. refs
(ONERA, TP NO. 1988-27)

A finite-difference method is used to solve the transmission line equations modeling the junction phase between a discharge channel and the ground. The channel resistance parameters are obtained by the classical laws of gas discharge physics. The results are found to agree well with experimental data for the cases of surface discharge and long air gap discharge. R.R.

A89-29273#
INTERPRETATION OF AN EXPERIMENTAL SPEARHEAD SHAPE ICE FORMATION BY USING A NUMERICAL MODEL
L. BRUNET and D. GUFFOND (ONERA, Chatillon-sous-Bagneux, France) (Congres International sur le Givrage Atmospherique des Structures, 4th, Paris, France, Sept. 5-7, 1988) ONERA, TP, no. 1988-121, 1988, 7 p. refs
(ONERA, TP NO. 1988-121)

A numerical code that has been developed to describe ice formation is discussed. The model includes the profile shape change versus time, the ice roughness influence on the thermal exchange coefficient, the ice density variation along the profile, and the curve effect on the ice thickness computation. The model makes it possible to chose the growth direction on each point of the blade. The results from the model are compared to experimental ice shapes obtained in an icing wind tunnel. It is shown that the model is capable of explaining complex shapes, including spearhead shapes. R.B.

A89-31826#
THE SAFIR LIGHTNING MONITORING AND ALERT SYSTEM [SURVEILLANCE ET ALERTE FOUDRE, LE SYSTEME SAFIR]
P. RICHARD, P. LAROCHE, and A. SOULAGE (ONERA, Chatillon-sous-Bagneux, France) (Societe des Electriciens, des Electroniciens et des Radio-Electriciens, Journees d'Etude sur les Recents Progres dans les Recherches sur la Foudre, Gif-sur-Yvette, France, Nov. 23, 24, 1988) ONERA, TP, no. 1988-168, 1988, 9 p. In French. Research supported by DRET. refs
(ONERA, TP NO. 1988-168)

The principles, architecture, and applications of the SAFIR lightning monitoring and alert system are described. The system involves the long-distance real-time mapping of lightning discharges using electromagnetic interferometry, along with the ground-based measurement of the electrostatic field generated by storm clouds (permitting the risk of lightning to be evaluated). The system consists of one central station (for signal synchronization and processing) and three measurement stations. R.R.

N89-19779*# Kunz Associates, Inc., Albuquerque, NM.
GENERALIZED THREE-DIMENSIONAL EXPERIMENTAL LIGHTNING CODE (G3DXL) USER'S MANUAL Contractor Report, 1981 - 1986
KARL S. KUNZ Feb. 1986 145 p
(Contract NAS1-16591)
(NASA-CR-166079; NAS 1.26:166079; KAI-R-1) Avail: NTIS HC A07/MF A01 CSCL 04B

Information concerning the programming, maintenance and operation of the G3DXL computer program is presented and the theoretical basis for the code is described. The program computes time domain scattering fields and surface currents and charges induced by a driving function on and within a complex scattering object which may be perfectly conducting or a lossy dielectric. This is accomplished by modeling the object with cells within a three-dimensional, rectangular problem space, enforcing the appropriate boundary conditions and differencing Maxwell's equations in time. In the present version of the program, the driving function can be either the field radiated by a lightning strike or a direct lightning strike. The F-106 B aircraft is used as an example scattering object. M.G.

N89-19782# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
A PRELIMINARY STUDY OF PRECURSORS TO HUNTSVILLE MICROBURSTS
M. A. ISAMINGER 25 Oct. 1988 29 p
(Contract DTFA01-80-Y-10546)
(AD-A200914; ATC-153; DOT/FAA/PM-87/35) Avail: NTIS HC A03/MF A01 CSCL 01C

Automated algorithms are being developed for the detection of wind shears such as microbursts and gust fronts. Previous studies have shown that these outflows can be hazardous to an airplane during takeoffs and landings. The ultimate goal of a microburst detection algorithm is the timely warning of potentially hazardous wind shears through the detection of reliable precursors. Research in Colorado and Oklahoma documented the significance of precursors such as descending reflectivity cores, convergence, rotation, and reflectivity notching as indicators that a mircroburst will occur in the very near future. The overall importance of an individual feature varies between regions. This investigation will focus on those precursors which play a dominant role in the formation of wet microbursts in the southeastern United States. The data analyzed in this report was gathered by the FAA TDWR S-band Doppler radar during 1985 and 1986 in Memphis, Tennessee, and Huntsville, Alabama. GRA

N89-19783*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A WIDE BANDWIDTH ELECTROSTATIC FIELD SENSOR FOR LIGHTNING RESEARCH
KLAUS P. ZAEPFEL Jan. 1989 12 p Presented at the Conference on Lightning and Statis Electricity, Dayton, OH, 24-26 Jun. 1986 Previously announced in IAA as A86-50260
(NASA-TM-101539; NAS 1.15:101539) Avail: NTIS HC A03/MF A01 CSCL 04B

Data obtained from UHF radar observation of direct-lightning strikes to the NASA F-106B aircraft have indicated that most of the 690 strikes acquired during direct-strike lightning tests were triggered by the aircraft. As an aid in understanding the triggered lightning process, a wide bandwidth electric field measuring system was designed for the F-106B by implementing a clamped-detection signal processing concept originated at the Air Force Cambridge Research Lab in 1953. The detection scheme combines the signals from complementary stator pairs clamped to zero bolts at the exact moment when each stator pair is maximally shielded by the rotor, a process that restores the dc level lost by the charge amplifier. The system was implemented with four shutter-type field mills located at strategic points on the aircraft. The bandwidth of the system was determined in the laboratory to be from dc to over 100 Hz, whereas past designs had upper limits of 10 to 100 Hz. To obtain the undisturbed electric field vector and total aircraft charge, the airborne field mill system is calibrated by using techniques involving results from ground and flight calibrations of the F-106B, laboratory tests of a metallized model, and a finite difference time-domain electromagnetic computer code. Author

15

MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A89-28536* Massachusetts Inst. of Tech., Cambridge.
DESIGN OF FEEDBACK CONTROL SYSTEMS FOR STABLE PLANTS WITH SATURATING ACTUATORS
PETROS KAPASOURIS, MICHAEL ATHANS, and GUNTHER STEIN (MIT, Cambridge, MA) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume

1. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 469-479. Research supported by the General Electric Co. Previously announced in STAR as N88-20050. refs
(Contract NAG2-297)

A systematic control design methodology is introduced for multi-input/multi-output stable open-loop plants with multiple saturations. This new methodology is a substantial improvement over previous heuristic single-input/single-output approaches. The idea is to introduce a supervisor loop so that when the references and/or disturbances are sufficiently small, the control system operates linearly as designed. For signals large enough to cause saturations, the control law is modified in such a way as to ensure stability and to preserve, to the extent possible, the behavior of the linear control design. Key benefits of this methodology are: the modified compensator never produces saturating control signals, integrators and/or slow dynamics in the compensator never windup, the directional properties of the controls are maintained, and the closed-loop system has certain guaranteed stability properties. The advantages of the new design methodology are illustrated in the simulation of an academic example and the simulation of the multivariable longitudinal control of a modified model of the F-8 aircraft.

A89-28595
CONTROLLER REDUCTION METHODS MAINTAINING PERFORMANCE AND ROBUSTNESS
JOHN B. MOORE, ANDREW J. TELFORD (Australian National University, Canberra, Australia), and UY-LOI LY (Boeing Co., Seattle, WA) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 1159-1164. Research supported by the Defence Science Technology Organization. refs

Standard balanced-truncation or Hankel-norm model approximation methods are applied to augmentations of the controller which emerge when characterizing the class of all stabilizing controllers in terms of an arbitrary proper stable transfer function. In the method, scaling parameters are at the disposal of the engineer to achieve an appropriate compromise between preserving performance for the nominal plant and a certain type of robustness of plant variations. There are a number of unique features of the approach. One feature is that a straightforward reoptimization of a reduced-order controller is possible within the framework of the method. A second feature is that for controllers designed for simultaneous stabilization of a number of plants, the method seeks to preserve the performance/robustness of the reduced-order controller for each plant. I.E.

A89-28621
PARALLEL IMPLEMENTATION OF REAL-TIME CONTROL PROGRAMS
PHILLIP L. SHAFFER (GE Control Systems Laboratory, Schenectady, NY) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 1449-1454. refs

Two turbojet engine control programs were analyzed for potential parallelism. Both were subjected to global, hierarchical, large-grain data-flow analysis, using internally developed dataflow analysis tools. Execution times of constituent code segments or procedures were determined, either by graph analysis for maximum execution time, or by accurate measurement. Data dependencies were combined with execution times to determine maximum possible speedup, using the length of the critical path as the shortest possible execution time. The first control program was divided into 199 code segements, and had a maximum speedup of 7.2. The second program consisted of 64 basic control procedures; this program has a maximum possible speedup of 5.3. The amount of data passed between the dependent tasks was small, averaging 1.3 values per dependency. Static, nonpreemptive schedules have been determined using a heuristic algorithm based on the critical path method. For the first control program this allowed a speedup of 6.6 using 7 processors; for the second control program, the maximum possible speedup of 5.3 was achieved using 6 processors. The first program is being implemented in parallel on a shared-memory bus-based multiprocessor. I.E.

A89-28627
ON THE IMPROVEMENT OF THE ADAPTION BEHAVIOR OF RECURSIVE PARAMETER ESTIMATION ALGORITHMS THROUGH NON-LINEAR, DYNAMIC PRE-CONTROL
PETER BECKER (Diehl GmbH und Co., Roethenbach an der Pegnitz, Federal Republic of Germany) IN: IEEE Conference on Decision and Control, 27th, Austin, TX, Dec. 7-9, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 1540, 1541.

A method is introduced for improving the tracking or identification behavior of recursive parameter estimation algorithms. The method utilizes available, measured information from the process or information which acts on the process. The information is processed by a nonlinear, dynamic precontrol algorithm. Measurement updates are transformed into approximate parameter updates that are used as reference values in the classical estimation algorithm. Aircraft control has been chosen as an application example, and 6-degree-of-freedom simulation results are excellent. I.E.

A89-29130
ON THE REDUCTION OF DIRICHLET-NEWTON PROBLEMS TO WING EQUATIONS
M. G. EL SHEIKH (King Abdulaziz University, Jeddah, Saudi Arabia) and H. E. GAD-ALLAH (Ain Shams University, Cairo, Egypt) Quarterly Journal of Mechanics and Applied Mathematics (ISSN 0033-5614), vol. 41, Nov. 1988, p. 535-545. refs

This paper illustrates through a typical example how to reduce boundary-value problems with several Dirichlet-Newton conditions to systems of standard wing equations. The reduction of such equations into systems of algebraic equations has been standardized. Author

A89-29529
AIRCRAFT AND CLOUD SKY SIMULATOR
ALEXANDER AKERMAN, III and GEORGE A. HOFFMAN, JR. (I-MATH Associates, Inc., Orlando, FL) IN: Infrared scene simulation: Systems, requirements, calibration, devices, and modeling; Proceedings of the Meeting, Orlando, FL, Apr. 4-6, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 217-225.

A capability for generating sky images containing both clouds and aircraft has been developed through concatenating a variety of models and matting them to an image array processor. A family of apparent images are generated, each at a specific wavelength, whose gray scale values are in terms of absolute radimetric units. These images can then be combined as weighted sums to represent the appropriate spectral distributions for a specific sensor of interest. For example, this simulator has been used to generate sky scenes as inputs to a color CCD camera emulation. Author

A89-30683#
AN EXPERIMENTAL STUDY OF NOISE BIAS IN DISCRETE TIME SERIES MODELS
J. J. HOLLKAMP and S. M. BATILL (Notre Dame, University, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 317-326. refs
(AIAA PAPER 89-1193)

An algorithm is presented for the parameter identification of discrete time series models which predict the transient response of structures subject to arbitrary inputs. The linear structure transfer function is given in the form of an ARMA discrete time series model. Experimental results obtained for a subscale sailplane demonstrate the accuracy of the present completely automated method. R.R.

A89-30687#
TIME SERIES MODELS FOR NONLINEAR SYSTEMS
J. J. HOLLKAMP and S. M. BATILL (Notre Dame, University, IN) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 362-370. Research supported by the University of Notre Dame and USAF. refs
(AIAA PAPER 89-1197)

Discrete time series models can be used for transient response prediction of linear structures. When structural nonlinearities are present it may be possible to modify the form of the discrete time series model to account for the nonlinearities. One approach is to allow the model parameters to become functions of state. This paper explores some possible forms of the parameter functions for various nonlinear structures. Numerical case studies using both a Duffing Oscillator and a combined viscous and coulomb damped oscillator are presented. Also experimental data from a highly nonlinear aircraft landing gear strut are used to evaluate different model forms. The results from these studies show the potential improvements associated with the nonlinear models when compared to linear models. Author

A89-30700*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
EFFECT OF CONTROL SURFACE MASS UNBALANCE ON THE STABILITY OF A CLOSED-LOOP ACTIVE CONTROL SYSTEM
E. NISSIM (NASA, Flight Research Center, Edwards, CA) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 476-486. refs
(AIAA PAPER 89-1211)

An inertial energy approach similar to the aerodynamic energy method for flutter suppression is used to investigate the effects of mass-unbalanced control surfaces on the stability of a closed-loop system. It is demonstrated that a spanwise section for sensor location can be obtained which ensures minimum sensitivity to the mode shapes of the aircraft. Leading-edge control is characterized by a compatibility between inertial stabilization and aerodynamic stabilization that trailing-edge control lacks. R.R.

A89-30703#
APPLICATION OF HIGHER HARMONIC CONTROL (HHC) TO HINGELESS ROTOR SYSTEMS
KHANH NGUYEN and INDERJIT CHOPRA (Maryland, University, College Station) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 507-520. refs
(Contract DAAL03-88-C-002)
(AIAA PAPER 89-1215)

A FEM is used to predict the vibratory hub loads of a helicopter rotor system in forward flight. In the method, airloads are determined using an unsteady aerodynamic model, and the rotor induced inflow is determined using a free wake model. Results obtained for a hingeless rotor illustrate that the blade flap, lag and torsion vibration characteristics, offset of the blade center of mass from the elastic axis, offset of the elastic axis from the quarter chord, and rotor thrust all significantly effect the actuator power requirement for higher harmonic control. R.R.

A89-30996
KNOWLEDGE-BASED JET ENGINE DIAGNOSTICS USING XMAN
TIMOTHY G. JELLISON, NIGEL S. PRATT, and RONALD L. DE HOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: Detection, diagnosis and prognosis of rotating machinery to improve reliability, maintainability, and readiness through the application of new and innovative techniques. Cambridge and New York, Cambridge University Press, 1988, p. 341-350.

The development and application of a knowledge-based system for jet engine diagnostics is discussed. XMAN, an expert maintenance tool, is shown to offer significant improvements to the maintenance technician's ability to interpret and act upon diagnostics information. XMAN offers an expert interface to the Comprehensive Engine Management System Increment IV (CEMS IV), the standard Air Force jet engine maintenance decision support system. The diagnostics procedures associated with interpreting CEMS IV data products, troubleshooting engine alarms generated by the on-engine monitoring system and CEMS IV, and isolating engine discrepancies are automated by XMAN using expert system technology. The application of XMAN to the A-10A aircraft TF34 engine supported by the Turbine Engine Monitoring System is addressed. Author

A89-31083*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
KNOWLEDGE-BASED SIMULATION FOR AEROSPACE SYSTEMS
RALPH W. WILL, NANCY E. SLIWA, and F. WALLACE HARRISON, JR. (NASA, Langley Research Center, Hampton, VA) IN: Machine intelligence and autonomy for aerospace systems. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, p. 167-189. refs

Knowledge-based techniques, which offer many features that are desirable in the simulation and development of aerospace vehicle operations, exhibit many similarities to traditional simulation packages. The eventual solution of these systems' current symbolic processing/numeric processing interface problem will lead to continuous and discrete-event simulation capabilities in a single language, such as TS-PROLOG. Qualitative, totally-symbolic simulation methods are noted to possess several intrinsic characteristics that are especially revelatory of the system being simulated, and capable of insuring that all possible behaviors are considered. O.C.

A89-31458*# Planning Research Corp., Hampton, VA.
DIGITAL ROBUST CONTROL LAW SYNTHESIS USING CONSTRAINED OPTIMIZATION
VIVEK MUKHOPADHYAY (Planning Research Corp., Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 175-181. Previously cited in issue 22, p. 3639, Accession no. A87-50551. refs
(Contract NAS1-18000)

A89-31459#
ESTIMATING PROJECTIONS OF THE PLAYABLE SET
T. L. VINCENT (Arizona, University, Tucson) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 182-187. Previously cited in issue 22, p. 3637, Accession no. A87-50408. refs

A89-31463*# Allied Bendix Aerospace, Teterboro, NJ.
MARKOV RELIABILITY MODELS FOR DIGITAL FLIGHT CONTROL SYSTEMS
JOHN MCGOUGH (Allied-Signal, Inc., Bendix Aerospace, Teterboro, NJ), ANDREW REIBMAN, and KISHOR TRIVEDI (Duke University, Durham, NC) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 12, Mar.-Apr. 1989, p. 209-219. refs
(Contract AF-AFOSR-84-0132; DAAG29-84-K-0045; NAG1-70)

The reliability of digital flight control systems can often be accurately predicted using Markov chain models. The cost of numerical solution depends on a model's size and stiffness. Acyclic Markov models, a useful special case, are particularly amenable to efficient numerical solution. Even in the general case, instantaneous coverage approximation allows the reduction of some cyclic models to more readily solvable acyclic models. After considering the solution of single-phase models, the discussion is extended to phased-mission models. Phased-mission reliability models are classified based on the state restoration behavior that occurs between mission phases. As an economical approach for the solution of such models, the mean failure rate solution method is introduced. A numerical example is used to show the influence of fault-model parameters and interphase behavior on system unreliability. Author

A89-31627
USING MISSION DECOMPOSITION TOOLS IN ADVANCED COCKPIT APPLICATIONS
MICHAEL N. STOLLINGS, RICHARD E. EDWARDS, and WILLIAM L. RANKIN (Boeing Advanced Systems, Seattle, WA) IN: Human Factors Society, Annual Meeting, 32nd, Anaheim, CA, Oct. 24-28, 1988, Proceedings. Volume 1. Santa Monica, CA, Human Factors Society, 1988, p. 140-144. refs
(Contract F33615-86-C-0537)
This paper describes an interactive, computer-based Mission Decomposition Tool (MDT) developed as part of the Cockpit Automation Technology Program. The purpose of this tool is to improve the efficiency of the crewstation design process. Specific activities supported by the MDT include generation and decomposition of air-to-air and air-to-ground mission scenarios; generation of mission event timelines; and post-flight analysis. The MDT strengthens the connection between analysis and test and evaluation activities in the areas of mission planning, pilot briefing, simulation set-up, performance assessment, and post-flight analysis. Author

A89-31905
VALIDATION OF IN-HOUSE AND ACQUIRED SOFTWARE AT AEROSPATIALE [VALIDATION DES CODES INTERNES ET EXTERNES A L'AEROSPATIALE]
J.-C. SOURISSEAU and J. LOCATELLI (Aerospatiale, Division Avions, Toulouse, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 3, 1988, p. 27-30. In French.
The validation of airframe-structure-modeling software at different stages of software development is discussed, with application of the coordination of projects involving the cooperation of different European countries. Special attention is given to the Aerospatiale finite element software. The standardization of the various codes employed to model the behavior of the A320 aircraft is also considered. R.R.

N89-18450# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
SOFTWARE DEVELOPMENT GUIDELINES
DENICE S. JACOBS *In* AGARD, Software Engineering and Its Application to Avionics 2 p Nov. 1988
Avail: NTIS HC A18/MF A01
Due to the growing complexity of avionic systems, the development cycle for mission critical software has evolved into a collective process of organized tasks. These tasks are distinct levels of effort which are implemented by the developer to ensure the creation of a reliable, operational system. Four principle tasks are summarized which have proven to be excellent procedures for developing avionics software. The first and foremost task of the project manager is to establish a Configuration Control Board (CCB) as the central core of technical management. It consists of a group of key hardware and software engineers who mutually govern the status of system development, and incorporate design changes on an agreed-to basis. The second task is to logically separate the software project into well-defined phases of development. This, too requires the cooperation of both hardware and software teams to work together in accordance with a master schedule. The third task is to create an automated data base which containes the latest interface specifications (ICDs) and system message definitions for use by the engineers. Finally, the last task is to procure hardware emulators and stand-alone test stations as an effective means of testing software prior to system integration and tests. Author

N89-18451# Thomson-CSF, Malakoff (France). RCM Div.
ON THE CONDITIONS AND LIMITS OF USER INTERVENTION IN DELIVERED SOFTWARE MANUFACTURER'S VIEWPOINT
JEAN R. CHARVOZ *In* AGARD, Software Engineering and Its Application to Avionics 12 p Nov. 1988
Avail: NTIS HC A18/MF A01
High capacity data processing architectures are now available in avionics. The development of embedded software have become a major activity in most avionic equipment manufacturing companies. These companies are faced with challenges. To meet customer requirements, the manufacturer often has to satisfy different, and sometimes contradictory, conditions. These issues include: the characteristic development of equipment which includes software (types, activities, tasks, skills, and facilities); the equivalency of software modification to a partial redevelopment and the difficulties inherent; and the conditions under which a customer may modify the software of the equipment. Some answers are provided to aspects of the process of giving a user the autonomy to perform software modifications. Author

N89-18453# Computer Sciences Corp., Falls Church, VA.
CONVERSION TO ADA: DOES IT REALLY MAKE SENSE
ROBERT A. CONVERSE and MITCHELL J. BASSMAN *In* AGARD, Software Engineering and Its Application to Avionics 5 p Nov. 1988
Avail: NTIS HC A18/MF A01
Change is an integral part of any useful operational system. Changes are required for any number of reasons, ranging from minor errors that exist in the system to major system upgrades to meet totally new and different requirements. For the U.S. Department of Defense (DOD), the manner in which systems are changed is of significant interest. Major system upgrades occur in virtually every system at various times during their operational lifetime. One way to manage the changes and to reduce the long term costs associated with them is the use of the Ada programming. Avionics is an application area withing DOD for which the use of Ada is a serious consideration. However, in addition to reducing the long term costs, the avionic software must also meet strigent real-time performance and resource utilization requirements. Some of the issues associated with the use of Ada to accomplish system changes are addresssed. Background and general issues will be discussed as well as some concerns that are specific to avionics systems. Author

N89-18455# British Aerospace Aircraft Group, Preston (England). Military Aircraft Div.
EMBEDDING FORMAL METHODS IN SAFRA
ANDREW BRADLEY *In* AGARD, Software Engineering and Its Application to Avionics 9 p Nov. 1988
Avail: NTIS HC A18/MF A01
The SAFRA software development method was used extensively and successfully for the production of real-time avionic systems at BAe Warton. The method couples a powerful, yet simple, semi-formal specification (CORE) and design (MASCOT) approach to provide an environment covering the complete life cycle. Embedding formal methods into this established approach will combine requirements capture and structuring techniques with mathematically formal specification and designs, facilitating mathematical proof of safety critical elements. Following an overview of SAFRA, a brief introduction is provided to formal methods and identifies Z, a method founded on set theory and logic, for detailed investigation. An interface between semi-formal and formal techniques is defined and the results of applying the combined method to a number of avionic specification studies are summarized and discussed. It is concluded by considering the potential benefits and costs of adopting formal methods on large scale, avionic software projects. Author

N89-18457# Shape Technical Center, The Hague (Netherlands).
THE STATE OF PRACTICE IN ADA-BASED PROGRAM DESIGN LANGUAGES
LAWRENCE G. JONES *In* AGARD, Software Engineering and Its Application to Avionics 6 p Nov. 1988
Avail: NTIS HC A18/MF A01
The use of Ada in avionics and other systems is assuming more importance due to a growing body of national policies dictating

its use in mission critical systems. This has created a need for software engineering techniques that incorporate Ada concepts so that the transition from a system design to an Ada implementation is more easily achieved. One of the most common techniques is to use an Ada-based program design language (ADL). The current state of practice in Ada-based program design languages is surveyed by examining some leading reports on the subject. Among the more important efforts, the surveys of existing ADLs conducted for the U.S. Naval Avionics Center (NAC), the Institute of Electrical and Electronics Engineers Recommended Practice for ADLs, the ADL guidelines produced for Transport Canada, and the ADL guidelines produced for NAC are discussed. It is noted that the state of practice is considered to be too immature for standardization. However, some of the major findings are summarized and point to future directions. Author

N89-18458# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
DEBUGGING DISTRIBUTED ADA AVIONICS SOFTWARE
MARC J. PITARYS *In* AGARD, Software Engineering and Its Application to Avionics 8 p Nov. 1988
Avail: NTIS HC A18/MF A01

Future avionics systems will consist of distributed fault-tolerant architectures. The operational flight software will be written in the Ada programming language and use a distributed operating system. Developing and maintaining this software requires new and innovative debugging techniques to reduce cost, time, and complexity. Two specific techniques are described. These are the dynamic trace buffers and the software Built-In-Support-Functions (BISFs). First the need for new approaches to debugging distributed Ada software is addressed. The implementation of each of the techniques is presented. The Avionics Laboratory is the only organization to successfully demonstrate both techniques with MIL-STD-1750A computers. Observations and recommendations for using these techniques will be reported. Author

N89-18459# Computer Technology Associates, Inc., Ridgecrest, CA.
AUTOMATED ADA CODE GENERATION FOR MILITARY AVIONICS
ROBERT S. ARDREY, II *In* AGARD, Software Engineering and Its Application to Avionics 9 p Nov. 1988
Avail: NTIS HC A18/MF A01

The experience with Ada-directed software development methodologies is presented. These include functional programming the use of class instances object-oriented design, and Ada as a program design language. Built upon prior experience, an automated Ada code generation environment is described. The environment addresses the enhancement of existing software tools, new development currently underway, and compiler support for military flight computers such as the AN/AYK-14. Finally, military avionics applications of such an environment are discussed. Predicted improvements in the areas of prototyping, productivity, reusability, and maintainability are examined. Author

N89-18460# Sparta, Inc., Laguna Hills, CA. Software and Systems Technology Div.
VERIFICATION AND VALIDATION OF FLIGHT CRITICAL SOFTWARE
PIO DEFEO and ANTHONY DETHOMAS (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.) *In* AGARD, Software Engineering and Its Application to Avionics 10 p Nov. 1988
Avail: NTIS HC A18/MF A01

The complexity and the fault tolerance requirements of flight critical systems are rapidly increasing. New techniques and methods must be developed and must be integrated with existing methods so that the rigorous technical objectives of the verification and validation process of such systems can be met at reasonable cost. Some of the advanced requirements of these systems are examined in critical areas for system architecture and software design. Some promising techniques are described which can effectively support architectural design and analysis and software development and verification. Author

N89-18463# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft and Helicopter Div.
THE MBB TEST STRATEGY AND TOOL SET FOR SOFTWARE AND SYSTEM INTEGRATION
HERMANN HESSEL and WALTER WAGNER *In* AGARD, Software Engineering and Its Application to Avionics 6 p Nov. 1988
Avail: NTIS HC A18/MF A01

Based on a generic system development concept a test strategy was established withing MBB Military Aircraft and Helicopter Division. In order to support this strategy a tool set was developed which is being used for all projects and throughout all development phases. Due to its free configurability it can easily be adapted to production line applications as well as to other purposes. Author

N89-18465# British Aerospace Aircraft Group, Warton (England). Military Aircraft Div.
THREE GENERATIONS OF SOFTWARE ENGINEERING FOR AIRBORNE SYSTEMS
A. O. WARD *In* AGARD, Software Engineering and Its Application to Avionics 11 p Nov. 1988
Avail: NTIS HC A18/MF A01

The serious practice of software engineering is a relatively recent phenomenon and there is a minimum of reported experience in the use of methods and tools to support its applications. The technology can be viewed as progressing through several generations typified by the form in which development information is stored and accessed and the nature of the life cycle. The former is described in terms of a file, data and a knowledge base, the latter as progressing from a phase to an object oriented life cycle. Experience with a typical first generation tool set is described briefly through the airborne software for the Experimental Aircraft Project. This is based largely on the use of structured methods for requirements and design, a programming support environment supporting the use of MASCOT and Pascal and rigorous management and control procedures. An advantageous cost benefit analysis of the project is reported. A move to the second generation of software engineering is being planned under the auspices of the Eurofighter Project by the adoption of an Integrated Project Support Environment (IPSE). The general characteristics of an IPSE are discussed including the tool interface and its relevance to emerging standardization activities such as CAIS and PCTE Plus. A longer term view of software is presented with an intimation of the scale and nature of future projects and a form of life cycle better suited to the needs. The requirements for software engineering to support artificial intelligence, safety critical applications, and rapid prototyping are reviewed. Author

N89-18466# Anchor Software Management, Falls Church, VA.
SOFTWARE READINESS PLANNING
JACK COOPER *In* AGARD, Software Engineering and Its Application to Avionics 6 p Nov. 1988
Avail: NTIS HC A18/MF A01

A method is presented wherein the capability to support and make changes to avionics system software during the readiness phase of its life cycle can be guaranteed. In recognizing that the supportability of the software is completely determined during its development, the method centers around pre-development planning, decisions, and actions on the part of the avionics system's acquisition manager. Discussed are the software engineering considerations that must be included in the contract to facilitate the future supportability of the software. That is followed by a description of contractual requirements to be placed on the software support environment used to develop the avionics software to ensure the life cycle supportability of the target avionics software. Two tools, a management Plan and a contracting Standard, that supported the method for ensuring software supportability are described. The Plan provides a vehicle for joint, customer and contractor, management of the developmental software support environment. The Standard provides the contractural life cycle supportability requirements. Author

N89-18467# Control Data Corp., Minneapolis, MN.
AN AVIONICS SOFTWARE EXPERT SYSTEM DESIGN
JUDY L. BRINK and RONALD B. HAYNES (Rome Air Development Center, Griffiss AFB, NY.) *In* AGARD, Software Engineering and Its Application to Avionics 8 p Nov. 1988
Avail: NTIS HC A18/MF A01

The scope is to define an expert software system, implemented in Ada, for avionics in the 1990's, using a table-driven design that was developed in a demonstration program as the prototype, in order to support tactical decision making applications. As a synopsis of what follows it will: point out the relevancy to the avionics community; give a historical example of a table-driven design in the area of reconnaissance management systems; describe the design logic behind this historical example by providing a single thread through the system; discuss the conceptual enhancements that need to be folded on top of this historical example, as an additional layer, in order to produce an expert software system; and provide a summary highlighting some reasons the avionics community should move in this direction from a software perspective. Author

N89-18475# Agusta Sistemi S.p.A., Tradate (Italy).
ROBUST ALGORITHM SYNCHRONIZES MODE CHANGES IN FAULT-TOLERANT ASYNCHRONOUS ARCHITECTURES
ANTONIO SILVA *In* AGARD, Software Engineering and Its Application to Avionics 8 p Nov. 1988
Avail: NTIS HC A18/MF A01

The need for protection against common-mode failures, in hardware and in software, as well as the need to cut hardware costs and complexity, has led to redundant asynchronous architectures. The resulting random phase sampled-data systems are loosely coupled, reducing fault propagation, but need to make homogeneous decisions whenever certain event combinations occur. Since decisions are basically boolean operations, a method was developed to achieve homogeneous agreement on discrete signals, without imposing constraints on input or architectural characteristics to the system designer. The method saves the critical problem of synchronized change of operational mode in avionic systems, where a safe all or none way of making decisions is of primary importance. Author

N89-19236*# Boeing Military Airplane Development, Seattle, WA.
EXTENSIONS AND IMPROVEMENTS ON XTRAN3S
C. J. BORLAND *In* NASA, Langley Research Center, Transonic Unsteady Aerodynamics and Aeroelasticity 1987, Part 1 p 15-45 Feb. 1989
Avail: NTIS HC A12/MF A01 CSCL 09B

Improvements to the XTRAN3S computer program are summarized. Work on this code, for steady and unsteady aerodynamic and aeroelastic analysis in the transonic flow regime has concentrated on the following areas: (1) Maintenance of the XTRAN3S code, including correction of errors, enhancement of operational capability, and installation on the Cray X-MP system; (2) Extension of the vectorization concepts in XTRAN3S to include additional areas of the code for improved execution speed; (3) Modification of the XTRAN3S algorithm for improved numerical stability for swept, tapered wing cases and improved computational efficiency; and (4) Extension of the wing-only version of XTRAN3S to include pylon and nacelle or external store capability. Author

N89-19842*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH. Avionics Lab.
A PARALLEL EXPERT SYSTEM FOR THE CONTROL OF A ROBOTIC AIR VEHICLE
DONALD SHAKLEY and GARY B. LAMONT (Air Force Inst. of Tech., Wright-Patterson AFB, OH.) *In* NASA. Lyndon B. Johnson Space Center, 2nd Annual Workshop on Space Operations Automation and Robotics (SOAR 1988) p 179-186 Nov. 1988
Avail: NTIS HC A22/MF A01 CSCL 09B

Expert systems can be used to govern the intelligent control of vehicles, for example the Robotic Air Vehicle (RAV). Due to the nature of the RAV system the associated expert system needs to perform in a demanding real-time environment. The use of a parallel processing capability to support the associated expert system's computational requirement is critical in this application. Thus, algorithms for parallel real-time expert systems must be designed, analyzed, and synthesized. The design process incorporates a consideration of the rule-set/face-set size along with representation issues. These issues are looked at in reference to information movement and various inference mechanisms. Also examined is the process involved with transporting the RAV expert system functions from the TI Explorer, where they are implemented in the Automated Reasoning Tool (ART), to the iPSC Hypercube, where the system is synthesized using Concurrent Common LISP (CCLISP). The transformation process for the ART to CCLISP conversion is described. The performance characteristics of the parallel implementation of these expert systems on the iPSC Hypercube are compared to the TI Explorer implementation. Author

N89-19894# Rolls-Royce Ltd., Derby (England). Performance Systems Dept.
COMPASS: A GENERALIZED GROUND-BASED MONITORING SYSTEM
M. J. PROVOST 30 May 1988 13 p Presented at the AGARD PEP 71st Symposium on Engine Condition Monitoring, Quebec, Canada, 30 May-3 Jun. 1988
(PNR90483; ETN-89-93681) Avail: NTIS HC A03/MF A01

The condition monitoring and performance analysis software system (COMPASS) is a ground based computer system being developed for application on the Rolls Royce RB211-542G and IAE V2500 turbofans. The diagnostic routines and the general host routines are described. The use of the general host routines could be extended to cover any operation which is to be monitored. Measures adopted to enable the COMPASS host to be made available for widespread application are outlined. ESA

N89-19899*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH-SPEED REAL-TIME ANIMATED DISPLAYS ON THE ADAGE (TRADEMARK) RDS 3000 RASTER GRAPHICS SYSTEM
WILLIAM M. KAHLBAUM, JR. and KATRINA L. OWNBEY Washington Apr. 1989 48 p
(NASA-TM-4095; L-16504; NAS 1.15:4095) Avail: NTIS HC A03/MF A01 CSCL 09B

Techniques which may be used to increase the animation update rate of real-time computer raster graphic displays are discussed. They were developed on the ADAGE RDS 3000 graphic system in support of the Advanced Concepts Simulator at the NASA Langley Research Center. These techniques involve the use of a special purpose parallel processor, for high-speed character generation. The description of the parallel processor includes the Barrel Shifter which is part of the hardware and is the key to the high-speed character rendition. The final result of this total effort was a fourfold increase in the update rate of an existing primary flight display from 4 to 16 frames per second. Author

16

PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A89-29185#
SCATTERING OF ACOUSTIC AND ELECTROMAGNETIC WAVES BY AN AIRFOIL
R. T. LING and T. D. SMITH (Northrop Corp., Aircraft Div.,

Hawthorne, CA) AIAA Journal (ISSN 0001-1452), vol. 27, March 1989, p. 268-273. Previously cited in issue 07, p. 1087, Accession no. A88-22130. refs

A89-29252#
MEASUREMENT OF MODEL PROPFAN NOISE IN HIGH SPEED WIND TUNNEL
H. GOUNET and S. LEWY (ONERA, Chatillon-sous-Bagneux, France) (Inter-Noise '88 Conference, Avignon, France, Aug. 30-Sept. 1, 1988) ONERA, TP, no. 1988-100, 1988, 5 p. Research supported by DRET and Service Technique des Programmes Aeronautiques. refs
(ONERA, TP NO. 1988-100)

A single-rotation 12-blade propfan whose blades were outfitted with pressure transducers has been tested in a transonic wind tunnel equipped with acoustic probes in order to ascertain both its acoustic and aerodynamic characteristics. The results thus obtained were compared with theoretical predictions for noise radiation. It is found that the nonanechoic environment of the wind tunnel degraded the acoustic results for far-field conditions; nevertheless, measurements in the propfan plane, around which noise radiation was maximum, appear to be valid. Substantial agreement is obtained between experimental results and both near- and far-field acoustic predictions. O.C.

A89-29253#
STUDY OF PROPAGATING ACOUSTIC SOURCES IN A FAN INTAKE BY MODAL ANALYSIS OF TONE NOISE
S. LEWY, S. CANARD, and P. KERVIEL (ONERA, Chatillon-sous-Bagneux, France) (Inter-Noise '88 Conference, Avignon, France, Aug. 30-Sept. 1, 1988) ONERA, TP, no. 1988-101, 1988, 5 p. Research supported by the Service Technique des Programmes Aeronautiques and SNECMA. refs
(ONERA, TP NO. 1988-101)

A new data processing scheme was developed for computing azimuthal wave-number spectra of noise generated in circular or annular ducts; in this method, positive and negative modes are separated. Examples are presented demonstrating that this method makes it possible to characterize the fan or compressor acoustic sources and duct linings. Moreover, the parasitic effects of flow distortions, due to deficiencies of static test benches, can be clearly distinguished and thus can be eliminated from the results. I.S.

A89-29254#
EXACT AND SIMPLIFIED COMPUTATION OF NOISE RADIATION BY AN ANNULAR DUCT
S. LEWY (ONERA, Chatillon-sous-Bagneux, France) (Inter-Noise '88 Conference, Avignon, France, Aug. 30-Sept. 1, 1988) ONERA, TP, no. 1988-102, 1988, 7 p. Research supported by the Service Technique des Programmes Aeronautiques and SNECMA. refs
(ONERA, TP NO. 1988-102)

A simplified exact computation technique for predicting noise radiation for an annular duct was developed on the basis of the approach described by Hamdi and Ville (1982). Results obtained for radiation in rearward arc agreed well with the ones obtained by the original code. It is shown that angles and levels of maximum noise directivity collapse on single curves, as a function of cut-off parameter, a conclusion similar to those deduced by previous investigators for cylindrical ducts. I.S.

A89-29280#
PREDICTION OF ROTOR BLADE-VORTEX INTERACTION NOISE FROM 2-D AERODYNAMIC CALCULATIONS AND MEASUREMENTS
M. CAPLOT (ONERA, Chatillon-sous-Bagneux, France) and J. HAERTIG (Saint-Louis, Institut Franco-Allemand de Recherches, France) ONERA, TP, no. 1988-129, 1988, 20 p. Research supported by DRET. refs
(ONERA, TP NO. 1988-129)

The aerodynamic analysis used by the present numerical and experimental study of blade-vortex interactions is based on the computation of the velocity potential in a two-dimensional, incompressible, inviscid and unsteady flow. The pressure, lift, and drag coefficients deduced from theoretical instantaneous velocity field results obtained around a lifting Joukowski airfoil under the action of an incident vortex are compared with water tunnel measurements; good agreement is noted. Two-dimensional data are transformed in order to study the case of a helicopter rotor's parallel blade-vortex interaction. O.C.

A89-29351
ACOUSTIC ASPECTS OF A RADIAL DIFFUSER
J. DE KRASINSKI, S. SUN (Calgary, University, Canada), and W. WAWSZCZAK (Lodz, Politechnika, Poland) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 39, no. 5, 1987, p. 427-444. Research sponsored by NSERC. refs

This paper describes experimental research on the acoustical aspects of an axially-symmetrical radial diffuser. Tests were made at high subsonic and supersonic speeds at the diffuser entry, using compressed air. The results are analyzed from the point of view of the internal flow and Lighthill's theory of sound generated aerodynamically. The outstanding features of this diffuser are a high efficiency in subsonic and supersonic ranges and extreme shortness and powerful sound attenuating capacity. The noise level of a supersonic nozzle at Mach 4.0 was reduced from about 110 dB to 80 dB. Author

A89-30833#
SOUND TRANSMISSION OF STIFFENED COMPOSITE PANELS - HYGROTHERMAL EFFECT
CONSTANTINOS S. LYRINTZIS (San Diego State University, CA) and RIMAS VAICAITIS (Columbia University, New York) IN: AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, 30th, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 1749-1758. Research supported by the San Diego State University Foundation. refs
(AIAA PAPER 89-1358)

This paper presents an analytical study on dynamic response and structure-borne noise transmission of discretely stiffened panels from composite materials due to elevated temperatures, absorbed moisture and random external excitation. A modified transfer matrix procedure for composite stiffened flat panels including the hygrothermal effects is developed to obtain the required dynamic response solution. Ingestion of moisture and changes of temperature levels were taken to vary linearly with the swelling, which results in effective force resultants. The dynamic response is calculated from the total hygrothermal and mechanical loading environment. Modal decomposition is used to predict the interior noise transmission. The acoustic enclosure is taken to be rectangular in shape of which portion of the boundaries is elastic (composite material) while the remaining surface is acoustically rigid. Numerical results are presented for acousto-structural applications revealing the hygrothermal effect. Author

A89-31908*# Flow Research, Inc., Kent, WA.
SUPERSONIC PROPELLER NOISE IN A UNIFORM FLOW
WEN-HUEI JOU (Flow Research Co., Kent, WA) AIAA Journal (ISSN 0001-1452), vol. 27, April 1989, p. 385-390. refs
(Contract NAS2-9607)

The sound field produced by a supersonic propeller operating in a uniform flow is investigated. The main interest is the effect of the finite forward flight speed on the directivity of the sound field as seen by an observer on the aircraft. It is found that there are cones of silence on the axis of the propeller. The semiapex angles on these cones are equal fore and aft of the propeller plane, and depend on the tip Mach number only. The Fourier coefficients of the acoustic pressure contain the Doppler amplification factor. The sound field weakens in the upstream direction and strengthen downstream. Kinematic considerations of the emitted Mach waves not only confirm these results, but also provide physical insight into the sound generation mechanism. The predicted zone of silence and the Doppler amplification factor are compared to the theoretical prediction of shock wave formation and the flight test of the SR3 propeller. Author

N89-19143# Rolls-Royce Ltd., Derby (England).
ASYMPTOTIC ANALYSIS OF AEROENGINE TURBOMACHINERY NOISE
A. M. CARGILL 7 Mar. 1988 10 p Presented at the Institute of Acoustics Spring Meeting on Acoustics '88, Cambridge, England, 5-8 Apr. 1988
(PNR90489; ETN-89-93685) Avail: NTIS HC A02/MF A01

A noise analysis approach based on the existence of a small parameter that is of the same order as the ratio of blade chord or acoustic wavelength to duct diameter was developed. It is shown that by expansion of this small parameter the strip theory approximation arises and that the next order terms are due to the blade tips. The radiation is calculated by solving the radiation problem for a given circumferential mode by what is essentially ray theory. The advantages of this over the more familiar modal approach are stressed. ESA

17

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A89-29738
ECONOMIC PROBLEMS OF RAISING THE EFFECTIVENESS OF AIR FLIGHT SIMULATORS [OEKONOMISCHE PROBLEME DER ERHOEHUNG DER EFFEKTIVITAET VON LUFTFAHRTSIMULATOREN]
VIACHESLAV G. KOBA (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 6, 1988, p. 221-223, 227. In German. Translation.

Methodological aspects of flight simulator development are addressed with special emphasis on the economic aspect. An analytical method of assessing the social-economic effectiveness of a simulator is given. The application of the analysis to some practical examples is considered. C.D.

A89-30426
THE LEGAL BASES OF CAPACITY REGULATIONS FOR AIR TRAFFIC IN THE AIR AND AT AIRPORTS [RECHTSGRUNDLAGEN FUER KAPAZITAETSREGELUNGEN DES LUFTVERKEHRS IM LUFTRAUM UND AN FLUGPLAETZEN]
WALTER SCHWENK Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 37, Dec. 1988, p. 302-319. In German. refs

The provisions of FRG federal aviation law regulating traffic loads for airways and airports are surveyed, with a focus on their implications for the solution of current overcrowding problems. Solution proposals discussed include the extension of the airspace available to ATC, lowering the minimum separation between aircraft, stricter limitations on VFR traffic, displacement of some flights to less desirable airspace, establishment of a central airspace-use and flight-plan coordination office, civil-military cooperation, personnel improvements, cooperation with Eurocontrol, and privatization of ATC services. Also considered are changes in airport licensing, mandatory technological improvements, and regulations applied directly to different classes of airspace users. The need for EEC-level regulations to compensate for present and future EEC air-traffic liberalization measures is stressed. T.K.

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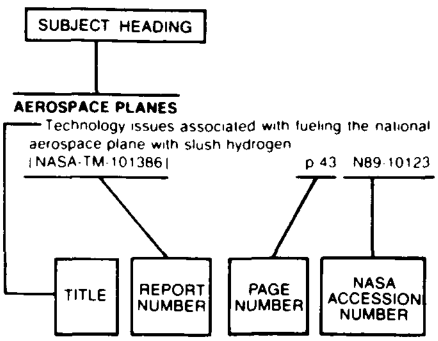

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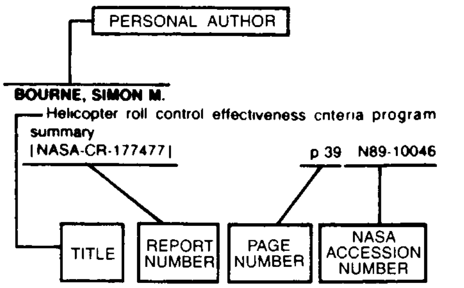

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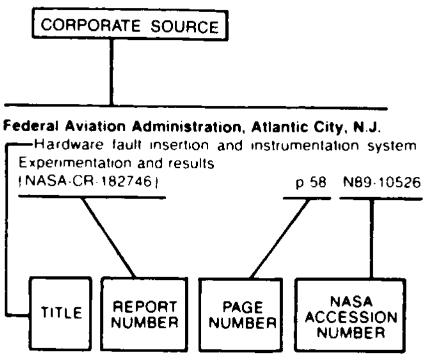

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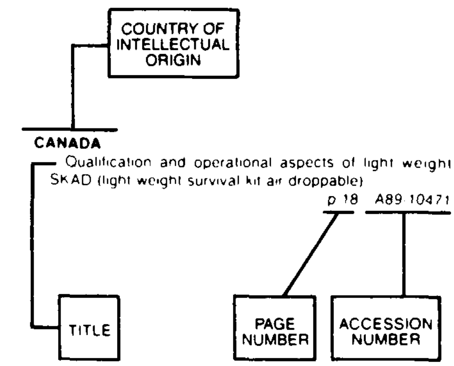

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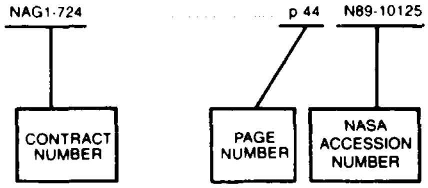

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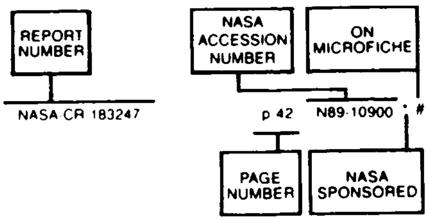

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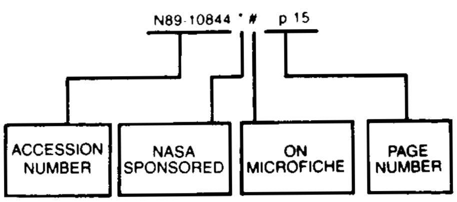

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(702) 784-6579

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NEWARK PUBLIC LIBRARY
5 Washington Street
Newark, NJ 07101-0630
(201) 733-7812

NEW MEXICO
UNIVERSITY OF NEW MEXICO
Zimmerman Library
Government Pub. Dept.
Albuquerque, NM 87131
(505) 277-5441

NEW MEXICO STATE LIBRARY
Reference Department
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826

NEW YORK
NEW YORK STATE LIBRARY
Empire State Plaza
Albany, NY 12230
(518) 474-5563

NORTH CAROLINA
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Davis Library
BA/SS Documents Division
Chapel Hill, NC 27515
(919) 962-1151

NORTH DAKOTA
UNIVERSITY OF NORTH DAKOTA
Chester Fritz Library
Documents Department
Grand Forks, ND 58202
(701) 777-4629
In cooperation with North Dakota State Univ. Library

OHIO
STATE LIBRARY OF OHIO
Documents Department
65 South Front Street
Columbus, OH 43266-0334
(614) 462-7051

OKLAHOMA
OKLAHOMA DEPT. OF LIB.
Government Documents
200 NE 18th Street
Oklahoma City, OK 73105
(405) 521-2502, ext. 252

OKLAHOMA STATE UNIV. LIB.
Documents Department
Stillwater, OK 74078
(405) 624-6546

OREGON
PORTLAND STATE UNIV. LIB.
Documents Department
P.O. Box 1151
Portland, OR 97207
(503) 229-3673

PENNSYLVANIA
STATE LIBRARY OF PENN.
Government Pub. Section
P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

TEXAS
TEXAS STATE LIBRARY
Public Services Department
P.O. Box 12927—Cap. Sta.
Austin, TX 78711
(512) 475-2996

TEXAS TECH. UNIV. LIBRARY
Govt. Documents Department
Lubbock, TX 79409
(806) 742-2268

UTAH
UTAH STATE UNIVERSITY
Merrill Library, U.M.C. 30
Logan, UT 84322
(801) 750-2682

VIRGINIA
UNIVERSITY OF VIRGINIA
Alderman Lib.—Public Doc.
Charlottesville, VA 22903-2498
(804) 924-3133

WASHINGTON
WASHINGTON STATE LIBRARY
Documents Section
Olympia, WA 98504
(206) 753-4027

WEST VIRGINIA
WEST VIRGINIA UNIV. LIB.
Documents Department
Morgantown, WV 26506-6069
(304) 293-3640

WISCONSIN
MILWAUKEE PUBLIC LIBRARY
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-3065

ST. HIST LIB. OF WISCONSIN
Government Pub. Section
816 State Street
Madison, WI 53706
(608) 262-4347

WYOMING
WYOMING STATE LIBRARY
Supreme Ct. & Library Bld.
Cheyenne, WY 82002
(307) 777-5919